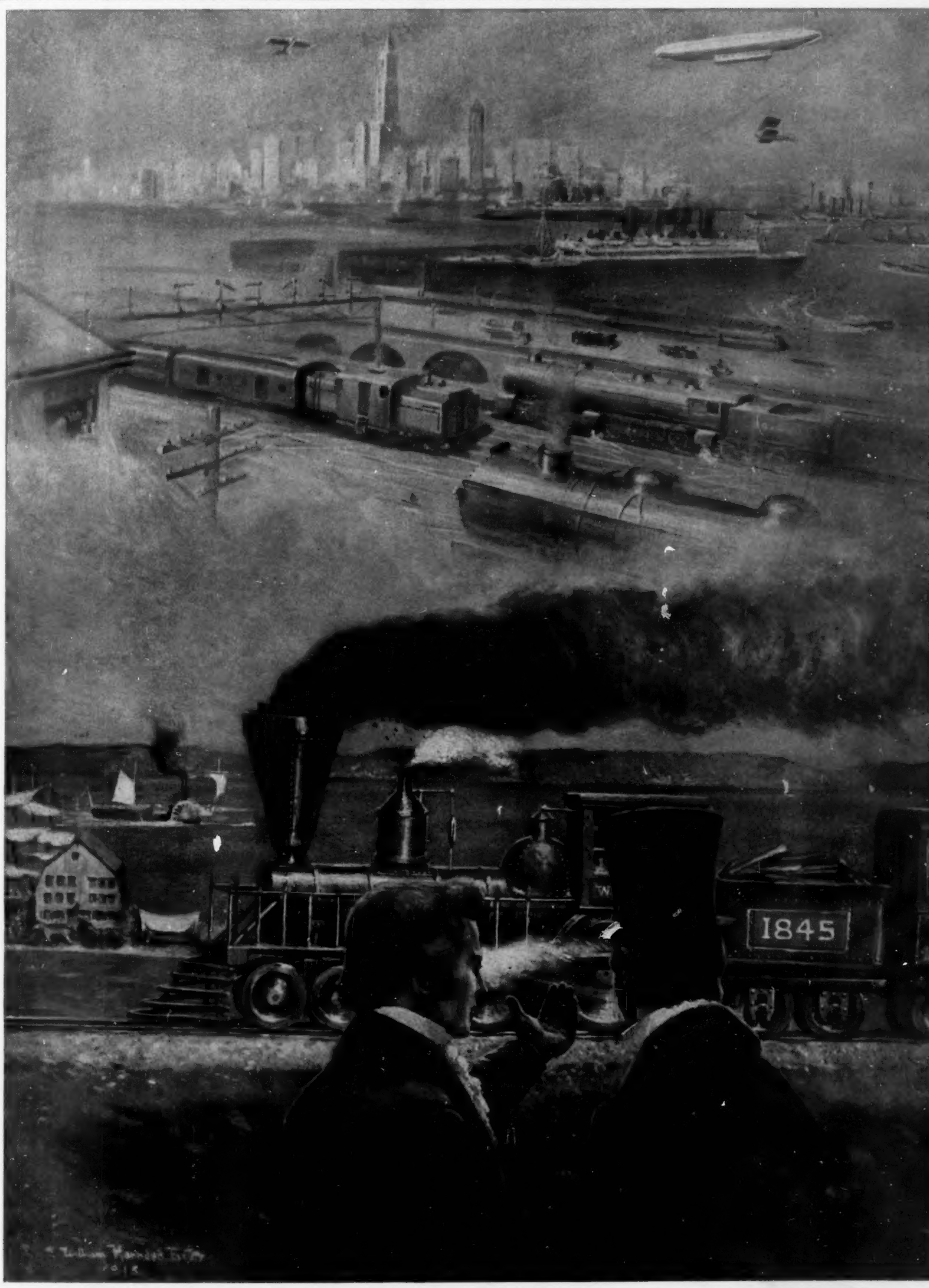
SCIENTIFIC AMERICAN

1845 — 70th Anniversary Number — 1915



Vol. CXII. No. 23
June 5, 1915

Munn & Co., Inc., Publishers
New York, N. Y.

Price 25 Cents
$3.00 A Year

Hupmobile for Nineteen Sixteen

$115 Lower in Price—$200 Greater in Value

These two facts about the 1916 Hupmobile make this the most important announcement this company has ever made.

The 1916 Hupmobile is priced at $1085—$115 less than our 1915 model.

Yet we have gone to greater lengths than ever before to maintain the Hupmobile reputation for quality. The new Hupmobile has twenty per cent more power, giving a quicker pickup, an even stronger pull on hills and in sand, and slower running on high speed. We have made many refinements throughout the chassis; increasing the quality and improving the workmanship everywhere. Note these mechanical features: Tungsten steel valves, disc clutch with 16 hardened steel plates, bronze-shell motor bearings, spiral bevel gears in rear axle, nickel steel axle shafts, vanadium steel mainleaf in springs, tubular propeller shaft. Compare these features of the $1085 Hupmobile with any car on the market.

The 1916 Hupmobile maintains the reputation of earlier Hupmobiles for economy. The total repair expense of 54,000 Hupmobiles now in service, including breakages due to accidents, is less than one-quarter cent per mile. The 1916 Hupmobile will probably reduce this average. Though twenty per cent more powerful the 1916 car is a fit companion for our earlier models in gasoline mileage, tire service, and oil consumption.

We have been told countless times that the 1915 Hupmobile is the easiest riding car ever built. The 1916 Hupmobile is more comfortable. The upholstery is deeper. Genuine high grade hair and improved cushion construction give the comfort of an old shoe. Springs are even more flexible and easy riding. We have moved the control levers forward to add roominess, and changed their shape to give easiest operation. Tires are large in proportion to weight. The 119 inch wheelbase cradles you over bumps and smooths rough roads.

We know you will be charmed with the perfect performance and the luxurious ease of the 1916 Hupmobile.

The upholstery is genuine high grade leather. The open bodies are lined, with no highly polished surface exposed to scratches or mars. Floor-boards and clear running boards are best linoleum. The tonneau is richly carpeted.

The new bodies have a depth of color and luster of finish you have heretofore seen only in highest priced cars. Fenders, radiator, and motor bonnet are enameled by a new process—beautiful and long wearing.

The 1916 Hupmobile has the famous Bijur system for electric starting and lighting. This equipment is used on some of the highest priced cars. Latest improved battery ignition—surest and simplest built—is used. In our own shops we build the genuine Goldie one man top and Collins quick-acting curtains. Five demountable rims, complete electric lighting equipment, latest and best speedometer, an exclusive design rain vision and ventilating windshield, Hupmobile patented tail light, genuine crown fenders, non-skid tires on the rear wheels, are regular equipment on the 1916 cars. You will find nothing that makes for completeness missing from the Hupmobile.

These many improvements in style and refinements in design we give you in the 1916 Hupmobile at $1085 for the five-passenger touring car or roadster. You considered the 1915 car a big value at $1200. Compared with our previous cars the 1916 model is not only a bigger value but it is offered you at a reduction of $115.

We have accomplished these two results so important to you—first, by pledging ourselves to a fifty per cent increase in production for 1916, which means we buy better materials cheaper and greatly reduce overhead cost per car; second, by increasing our factory facilities and improving factory methods—new machinery and new processes enable us to build better at lower factory cost; third, we are confident that no car on the market is sold on a narrower margin of profit than the 1916 Hupmobile.

In a word, in our 1916 cars we are giving you the saving we effect through reduced factory costs, reduced material costs, and an unusually low profit per car.

For 1916, too, we offer you a complete line of Hupmobiles. We are now prepared to give you any type of car your needs or your tastes may demand—five-passenger Touring Car, two-passenger Roadster, All-Year Touring Car or Coupe, seven-passenger Touring Car, seven-passenger Limousine, five-passenger Sedan. We have absolute confidence that each of these types is the best value at the price on the market—certainly the best value ever built by this company.

All types retain the Hupmobile steady-riding, low-hung chassis; all bodies are racy and distinctive in appearance; all models are highest quality in every detail of construction.

In considering the 1916 Hupmobile please remember that the Hupp Motor Car Company is one of the few manufacturers in the United States that have never built a poor car or had an off year. Wherever you go you will hear the Hupmobile spoken of as a car of most unusual value at its price. That is why "we believe the Hupmobile to be the best car of its class in the world." That creed of ours is fact to Hupmobile owners.

The reputation of quality in our cars is the biggest asset of our business. And we guard it most jealously.

So when we tell you the 1916 Hupmobiles are the best cars this company has ever built, and when we offer you our best cars at a reduction in price, you may well take our word for it that you will make no mistake in selecting a Hupmobile.

But we don't ask you to accept our word alone. We do ask you to see the 1916 Hupmobile—to ride in it—to drive it if you will.

Write for your copy of our new catalog which illustrates and describes in detail all the 1916 cars.

And won't you please ask the Hupmobile dealer in your city to prove to you every statement we make in this advertisement. Let him show you in an actual merit test that the 1916 Hupmobile is just what we say—truly "the best car of its class in the world."

1916 HUPMOBILE PRICES
Five-Passenger Touring Car, $1085
Roadster, $1085 · Sedan, $1365 · Limousine, $2365
All-Year Touring Car, $1185 · All-Year Coupe, $1165
Seven-Passenger Touring Car, $1225

PLEASE MAIL THIS COUPON
Hupp Motor Car Company, Detroit, Michigan:
Send me your complete catalog of 1916 cars.
Name ______
Address ______ *City and State* ______

HUPP MOTOR CAR COMPANY · DETROIT, MICHIGAN

President, Manager, Truck Buyer

You stimulate your Organization when you Supply it with High Quality Motor Trucks exclusively. You aid your men, and you keep them on their tip-toes. Quality machines will produce Quality results from the personnel of your Organization. You give your men the right tools to work with—they have the trucks they *want* and the trucks they *need*. Also you eliminate criticism, excuse making, and kicking from your Organization when you buy on a Basis of Quality, not Price.

If you don't buy the best, if you buy a Compromise Truck, and put it in the usual Organization you will get Compromise Results.

You are a good Strategist when you buy the Best Truck. Your Organization *can* make it pay and it's up to them to make good. The Right Truck, The Locomobile Truck, "The Best Built Truck in America" has *already* made good. Can you afford anything but the Best Truck?

3-Ton, 4-Ton, 5-Ton, 6-Ton

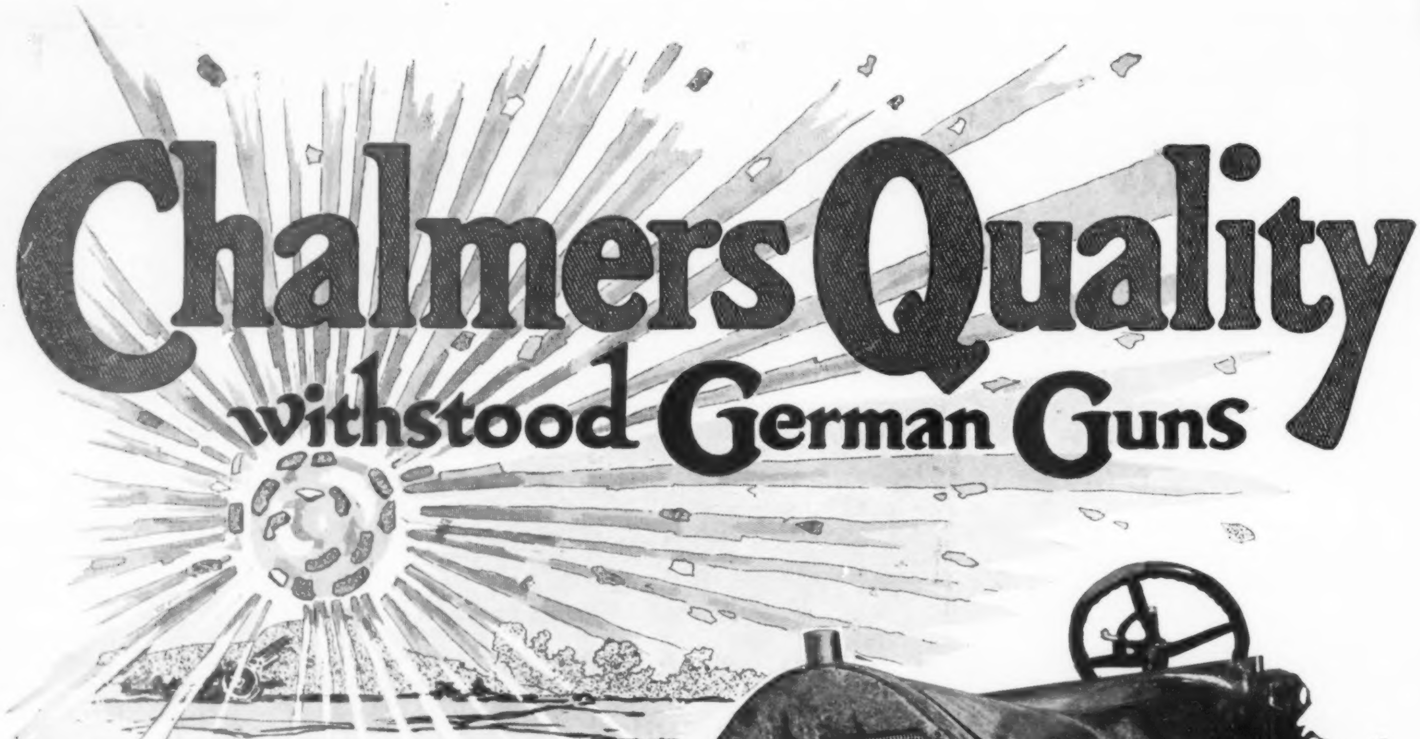
Locomobile Three and Four-Ton Worm Drive Trucks are available for prompt delivery. "The Best Built Truck in America" contains the finest Materials, exhibits the finest Workmanship, and has every advantage in Design. Indeed, what other Three and Four-Ton Trucks offer all these Features?

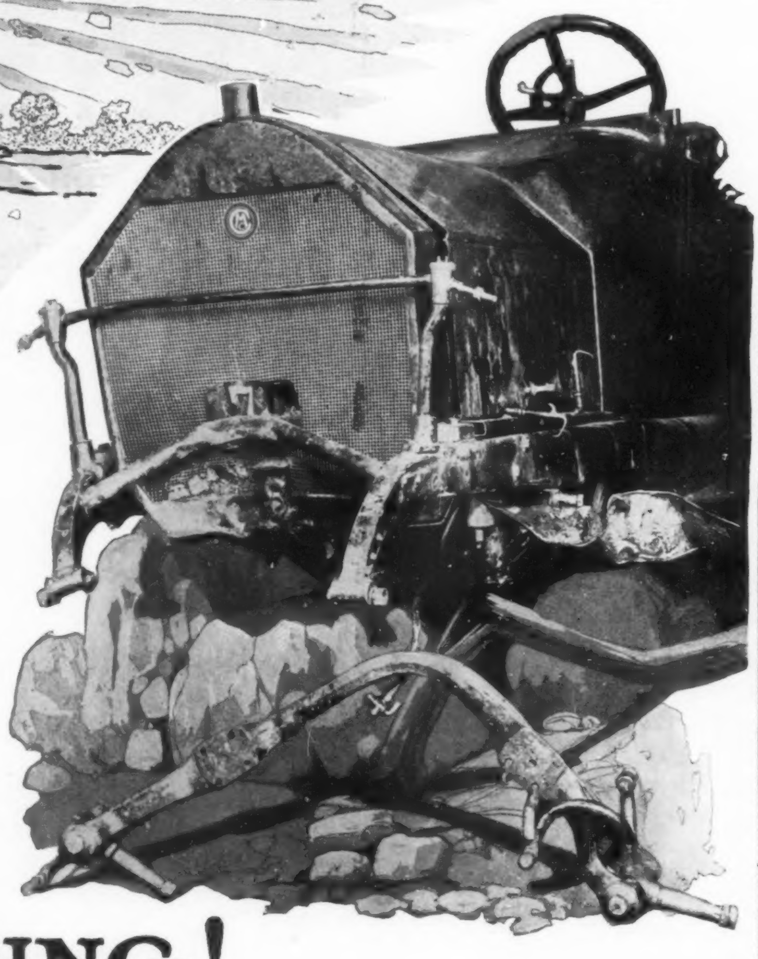
Worm Drive. Right Drive. Four-Cylinder Motor with Five Bearing Crank Shaft. Four Speeds and Reverse. Full Floating Rear Axle. Front Running Boards. Large Grease Cups. Heat Treated Pressed Chrome Nickel Steel Frame. Chrome Nickel Steel also for Crank Shaft, Connecting Rods, Valve Tappets and Rollers, Propeller Shafts, Gears, Gear Shafts, Live Axles. Two lengths Chassis. Wood Wheels Standard; Steel Wheels extra. Three-Ton Chassis, $3500 ($100 less than the average cost of the leading seven Three-ton Trucks). Four-Ton Chassis, $3,650.

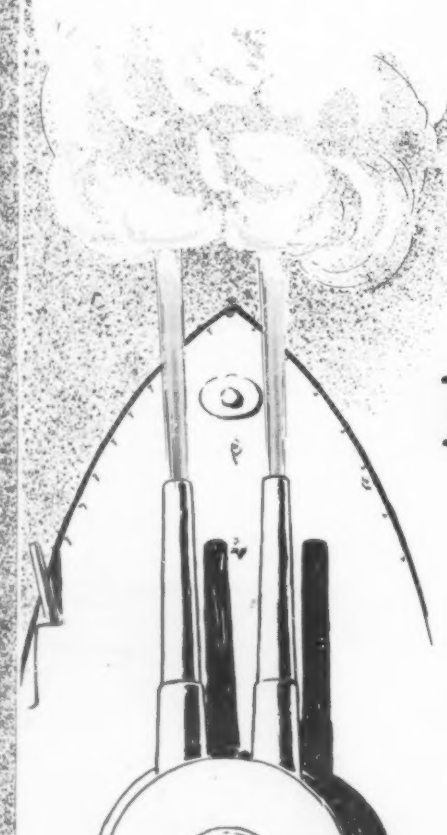
The Locomobile Truck has been designed and developed by the same men who produced "The Best Built Car in America," the famous Locomobile Touring Chassis. Our Trucks are used by: The United States Government, The British Government, The Russian Government, The Pennsylvania Railroad, Cities of Chicago, Vancouver, Baltimore and Seattle, State of Connecticut, United Fruit Company, National Fireproofing Company, Barrett Manufacturing Company, Cross, Austin & Ireland Lumber Company, Barber Asphalt Paving Company. We have delivered *hundreds* of Worm-drive Trucks this year.

The LOCOMOBILE COMPANY of AMERICA
BRIDGEPORT, CONN.

SEND FOR OUR TRUCK CATALOGUE OUR REPRESENTATIVE OR BOTH, WE GO ANYWHERE FOR BUSINESS







BING!

—a German shell struck a Chalmers Master-Six, knocked off a couple of wheels, one or two lamps and was pretty rough with the car altogether but—

There was enough left of this Chalmers to send back to San Francisco for repairs.

This Master-Six belonged to G. Menuel, Consul-General of the French Republic and was hit during the German bombardment of the French town of Papeete, Tahiti Island.

Chalmers cars are not built for targets nor to withstand the unusual demands of war, but they do stand up under rough usage and sometimes cruel abuse.

Chalmers quality is responsible for this.

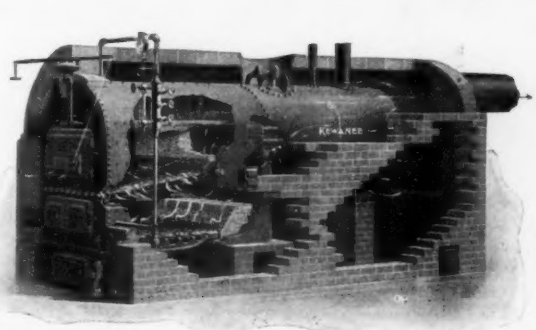
Chalmers Motor Company, Detroit, Mich.

"Let your next car be a Chalmers"

Cut Coal Costs by Burning Soft Coal Smokelessly

It is a fact, thoroughly proven, in buildings of all types, in all parts of the country, that the installation of a boiler that will burn soft coal smokelessly will reduce coal bills.

A dollar spent for soft coal buys more heat than the same money spent for hard coal. Government reports show that the anthracite coal, ordinarily used in large buildings, contains an average of 12,000 heat units a pound. It costs about $4.40 a ton, while soft coal, which costs about $4.00 a ton, contains about 14,000 heat units a pound. So, buying soft coal you get *more heat for less money.*



Sectional View Kewanee Smokeless Firebox Boiler (Brickset type) showing arrangement of double grate and long travel of gases.

Kewanee Smokeless Firebox Boilers are built with two grates, one above the other. Fuel is fed onto the top grate and the draft, which is downward, draws the gases down through the fire on the upper grate and over the hot coals on the lower grate. This burns all the heat-giving gases before they can be condensed into smoke.

Built in sizes correctly proportioned to heat from 1600 to 15,000 square feet of steam radiation, or from 2,600 to 24,500 square feet of hot water radiation.

Furthermore, smoke is an indication of wasted fuel—so a boiler that can burn soft coal smokelessly proves that it is wasting none of the coal.

KEWANEE Smokeless Boilers

are burning cheap soft coal in all kinds of buildings, and in all parts of the country, and are not making enough smoke to conflict with any smoke ordinance — no matter how rigid.

Kewanee Smokeless Boilers are not new, nor untried. On the contrary they are a combination of the firebox boiler and the down-draft grate construction known for years and approved by practically all engineers as the proper method of burning soft coal smokelessly and efficiently.

Let us send you our booklet "Cutting Coal Costs." Also a list of buildings where Kewanee Smokeless Boilers are reducing fuel bills.

Soft Coal for Heating Practical and Economical

When consideration is given to the fact that for every one thousand cubic feet of contents of the average building, about $2.00 is spent per year for the coal burned in the heating apparatus, it is easy to realize what a large percent of the operating cost of any building goes to the coal bill.

It, therefore, is the best of business on the part of any owner or prospective builder of a large apartment, or other type building, to study very carefully the question of coal and its relation to the boiler in which it will be used. And it has been demonstrated very conclusively that the coal cost of a building is an item that may be reduced, in some cases as much as 40%, by the installation of a boiler permitting the use and adaptable to the use of coal of highest value — cost considered.

Soft Coal Not Prohibited

Due probably to the fact that practically all cities of any size or importance are enforcing stringent ordinances against smoke, many people have a wrong impression that the use of soft coal is prohibited in certain cities. There is no ordinance, in any city, which says you must not burn soft coal. The furthest that any ordinance goes is to say that smoke will not be permitted and in such cases a type of boiler that will burn soft coal smokelessly is approved just as quickly for soft coal use as the ordinary type boiler for the use of anthracite or hard coal.

It is not a hardship to building owners for a city to enforce an ordinance prohibiting smoke. As a matter of real fact, legislations against smoke is an economy forced upon building owners.

Smoke is waste. It is sure proof that the boiler is not burning all of the fuel — and any ordinance, therefore, which prohibits smoke merely insists that building owners stop wasting fuel.

What Engineers Say About Smoke

Here is what some heating engineers say about smoke: "If nearly perfect combustion has taken place in the firebox of a boiler we are able to obtain an efficiency as high as 75 percent; by which is meant that 75 percent of the actual heat in fuel is utilized. The other 25 percent is a loss that cannot be avoided as it represents loss resulting from radiation and gases escaping into the stack which are necessary to cause draft."

"Whenever dense smoke issues from a stack we can safely say that it represents much of the actual heat value in the fuel (as smoke is nothing but particles of carbon carried from the boiler in gases insufficiently heated to burn)."

"Therefore, Mr. Owner is losing a big percentage of what he could save if his boiler was a type that would turn these escaping gases into heat by burning them at high temperature."

Soft Coal a Better Buy Than Anthracite

Dollar for dollar you get more heat by purchasing soft coal than when buying anthracite. The average run of mine soft coal, which costs in the neighborhood of $4.00 per ton, contains about 14,000 heat units per pound. In New York City (very close to hard coal mines) an anthracite coal, pea size, which contains about 12,000 heat units per pound costs about $4.40. That means that for about 40 cents less per ton you can get 2,000 heat units per pound more by buying soft coal. And in cities farther from the hard coal mines the difference is even more in favor of the purchase of soft coal.

There are two reasons, therefore, why a building owner should install a boiler which will burn soft coal smokelessly and these reasons apply whether his building is located in a city enforcing a smoke ordinance or not. First, soft coal costs less than anthracite. A given amount of money spent for soft coal buys more heat than the same money invested in anthracite. And when a boiler is installed that burns soft coal smokelessly it proves that it is wasting none of the fuel.

You Can Prevent Smoke

It is absolutely impossible to unscramble an egg, and it is just as impossible to burn smoke. The only remedy is to burn all of the elements that go to make smoke, and thus prevent smoke.

Chemistry teaches us that the result of complete combustion, or perfect burning of coal, is a colorless gas known as carbon-dioxide (CO_2). And an analysis of smoke shows that it is one part of carbon combined with one part of oxygen, or carbon monoxide (CO). In other words, one atom of carbon is capable of taking up two atoms of oxygen, and when this is accomplished the burning is complete. The black smoke which sails from some of the stacks is principally carbon monoxide — carbon which has taken up only one-half as much oxygen as it is capable of handling and from this atom of carbon, therefore, there has been only one-half of its full amount of heat produced.

Burning Soft Coal Smokelessly and Economically

About five years ago there was placed on the market a type of boiler that accomplishes all of these requirements admirably. It consumes soft coal so perfectly that almost no smoke is visible at the chimney and at the same time shows a boiler efficiency averaging about 20 percent higher than the usual type of heating boiler. The boiler referred to consists of an adaptation of the well-known Hawley down-draft furnace principle to a firebox or portable steel boiler. It consists of an upper grate made of heavy steel water tubes, built into the furnace and extending from the inside head-sheet to a cross header running from one side-sheet to the other. Below this is a lower grate of the usual rocking pattern that burns such half-consumed fuel as falls through from the upper grate.

In the operation of this type of boiler all of the coal is fired onto the water grate, and through this upper fire-door the greater part of the air is admitted, forming a draught down through the green coal and carrying the heat-giving gases down through the live fire and into the large combustion chamber where it is entirely consumed by the heat of the lower fire which is fed by the coked live coals which fall between the wide openings of the water grate. The combustion chamber back of the upper grate is large and high, giving the smoke a low velocity and ample time for perfect ignition before coming in contact with the cooler boiler plate.

The type of boiler referred to above has proven two things conclusively. First, that it can burn soft coal smokelessly and in conformity with any smoke ordinance ever passed, no matter how stringent. And it has also proven its ability to reduce fuel bills.

This is true not only in the west where anthracite or smokeless coals are hard to obtain and very high priced, but also in the eastern markets where hard coal is cheapest. Even in such cities as Pittsburgh, Philadelphia, New York, Baltimore and Washington, right in the heart of the hard coal region, this type of boiler, burning soft coal, has proven that it can supply heat cheaper than the ordinary type of boiler burning hard coal.

KEWANEE BOILER COMPANY

Kewanee, Illinois

CHICAGO NEW YORK ST. LOUIS KANSAS CITY MINNEAPOLIS

Pioneers in the Manufacture of Steel Firebox Boilers for the Smokeless Burning of Soft Coal

REG. U. S. PAT. OFF.

It has increased daylight in over 3,000 factories

Are the ceilings and walls of your factory covered with cold-water paint? If so, you probably find that it flakes and scales off. Very soon this will necessitate repainting. When that happens, why not give your ceilings and walls a bright glossy, tile-like finish, which will last for years without flaking and scaling?

Rice's Gloss Mill-White gives 19% to 36% more daylight; it is sanitary because it is *washable;* it makes employees more cheerful; saves money by making repainting less frequent. **By the "Rice Method" it can be applied over old cold-water paint.**

Over 3,000 of the biggest plants in the country use and praise "Barreled Sunlight"—firms like General Electric Co., Eastman Kodak Co., Hyatt Roller Bearing Co., etc. We can probably show you letters from many concerns in your own line of business.

Rice's is the *original* "mill-white." It now has many imitations, but they are all *varnish* gloss paints. Rice's is an *oil* paint—containing neither lead nor varnish—yet does not yellow like oil paint. It is made by a special process, discovered and owned exclusively by us. The tremendous advantages of this process enable us to make the following guarantee:

WE GUARANTEE that if Rice's does not remain white longer than any other gloss paint, applied at the same time and under the same conditions, *we will give, free, enough Rice's to repaint the job with one coat.* We also guarantee that, properly applied, Rice's will not flake or scale. You cannot lose under this guarantee.

***Write for booklet* "MORE LIGHT" *and* SAMPLE BOARD**

Sold direct from factory

Sold direct from our factory in barrels containing sufficient paint to cover 20,000 square feet—one coat.

RICE'S GLOSS MILL-WHITE

On concrete surfaces

On inside concrete Rice's Granolith makes the best possible primer for a second coat of Rice's Gloss Mill-White—giving a tile-like enamel finish at no more expense than lead and oil paint.

Rice's Granolith

U. S. GUTTA PERCHA PAINT CO.

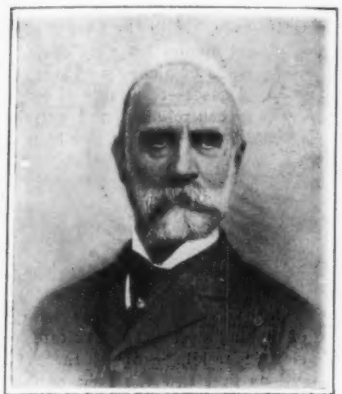
23 Dudley Street Providence, Rhode Island

SEVENTY-FIRST YEAR

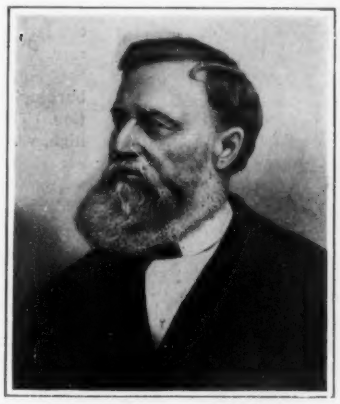
SCIENTIFIC AMERICAN

THE WEEKLY JOURNAL OF PRACTICAL INFORMATION

VOLUME CXII. NUMBER 23. | NEW YORK, JUNE 5, 1915 | 25 CENTS A COPY $3.00 A YEAR



Gordon McKay, inventor of the McKay shoe-making machines.

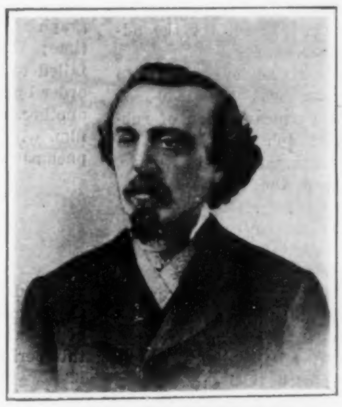


Isaac Singer, inventor of the Singer sewing machine.

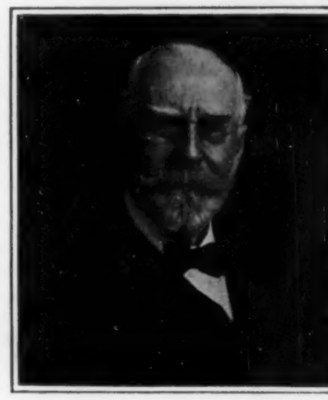
Lyman E. Blake, inventor of shoe-making machinery.

Charles Goodyear, inventor of the Goodyear lasting machinery.

Joseph Henry, who laid the foundation of the electric telegraph.

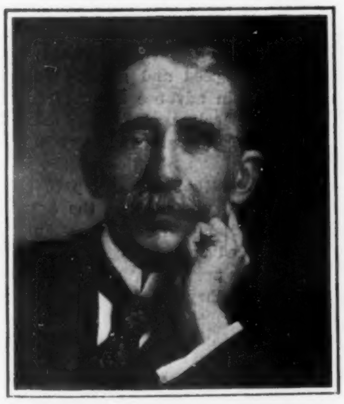


Charles J. Vandepoele, inventor of American overhead trolley system.



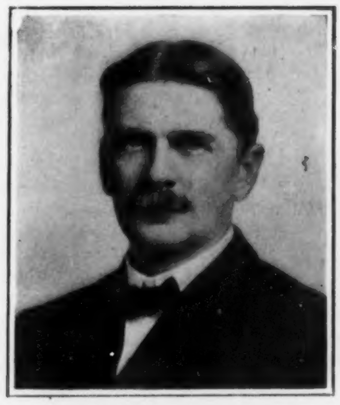
Dr. Coleman Sellers, pioneer motion picture and machine tool inventor.

Count von Zeppelin, inventor of the rigid airship.

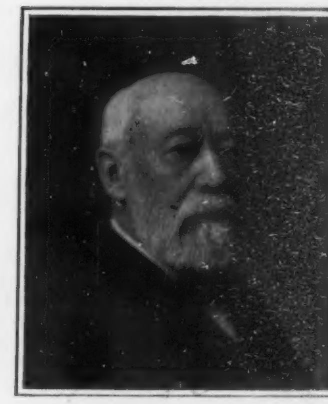


Prof. J. A. Fleming, inventor of the electric valve used in wireless.

James Gayley, inventor of the dry-blast process of steel making.

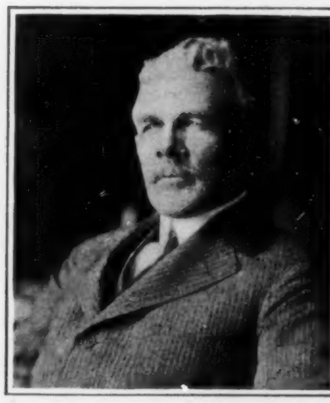


Charles E. Scribner, inventor of telephone switchboards.



J. S. Hyatt, an industrial chemist, who discovered celluloid.

Frank Sprague, inventor of the multiple unit system of train control,



Charles G. Curtis, inventor of the Curtis steam turbine.

Copyright by Edwin Levick

Dr. Rudolf Diesel, inventor of the Diesel engine.

Charles P. Steinmetz, inventor of the magnetite arc.

SOME GREAT INVENTORS OF THE PAST SEVEN DECADES

SCIENTIFIC AMERICAN

Founded 1845

NEW YORK, SATURDAY, JUNE 5, 1915

Published by Munn & Co., Incorporated. Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York.

Entered at the Post Office of New York, N. Y., as Second Class Matter
Entered as Second Class Matter at the Post Office Department, Canada.
Trade Mark Registered in the United States Patent Office

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Munn & Co., Inc., 233 Broadway, New York

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp* the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

The purpose of this journal is to record accurately, simply, and interestingly, the world's progress in scientific knowledge and industrial achievement.

Our Seventieth Anniversary

NOW that the SCIENTIFIC AMERICAN has reached the seventieth year of its existence, it seems fitting that we should pause and survey the progress that has been made by the world during that period. To do that most effectively one must transport one's self back seventy years—strip one's self of by far the greater part of the mechanism which we have come to accept as a matter of course. It has been said that the civilization and culture of Egypt, of Mesopotamia, five thousand years ago, was superior to that of London, Paris, or Rome one hundred years ago. Take away all the material advantages which have been given to us by science and invention and we drop back to a period where we have still not learned how to control matter and force.

When the SCIENTIFIC AMERICAN was established we had only Davy's arc and electrolysis, Oersted and Ampere's revelations in electrodynamics, Daguerre's photography, Henry and Faraday's work in induction, and Joule's mechanical equivalent of heat. The telegraph and the reaper had just been born. There was no telephone, no motion picture machine, no oil refining industry, no electric incandescent lamp, no wireless telegraph, no flying machine or airship, no typewriter, no automobile, no electric railway, no Bessemer steel, no phonograph, no passenger elevator, no steam turbine. Why continue the list any further? Much of the transformation which has marked the last seventy years has taken place within the lives of men still with us. The amazing rapidity with which industries have grown and conveniences multiplied may be attributed to the very nature of invention and research. Hardly was one discovery made when a vista to a whole series of new discoveries is opened, and each of these in turn disclosed bypaths to still newer fields. So development has progressed with the rapidity of wildfire.

And yet science and invention are young. Because they are, the SCIENTIFIC AMERICAN must remain perennially youthful.

What a period of scientific activity we have lived through! And yet all that we have witnessed is but a mere episode in the evolution that still lies before us. What discoveries and inventions we have still to see and record! When we think that at the time the SCIENTIFIC AMERICAN was started it took three weeks to send a message from New York to Liverpool and three months to Calcutta, when we think that only yesterday we marveled at the application of ether and chloroform to surgery, at the feat of telegraphing across the ocean without wires, at the bigness of the Panama Canal, at the opportunity of viewing the skeleton beneath the living flesh with the X-rays, and the spectacle of a man flying in the air swifter than any bird; when we think that it has been our privilege not merely to see these and many other miracles and to translate them into print, so that the wonder of them and the beauty of them might strike all men, who can blame us if we contemplate our future task with a feeling almost akin to awe? We have marveled at the discovery of radium and the breaking of the atom into corpuscles; at the tracing of diseases to the multiplication of infinitely small living things. Yet if we compare ourselves with those who will record the achievements of science a century hence, we in this day may seem to have progressed but little beyond the stage when the moon and the stars were to mankind but lanterns hung on a great tent wall and not separate worlds in infinite space.

The Greatest Ten Years of Invention

THE most significant event in the annals of human achievement was the invention of the steam engine. Its introduction divided recorded time into two distinctly defined eras, and it may well be said that the entire history of man's material endeavors counts forward or backward from that comparatively recent event. The jump from manual to power operations, which typifies the two eras, was nothing short of cataclysmic, and profoundly affected and stirred mankind in all its relations to an extent inconceivably greater than any political change or decision in battle that is ordinarily cited by the historian to mark the beginning of a new epoch.

As soon after this event as distracted civilization could be released from the stifling bondage of incessant warfare, the problem of applying this mighty agency to the needs of man began in earnest—with an energy, capacity, and genius never ceasing and never before equaled. Thus was inaugurated the age of machinery, of invention, of industrialism—an age vitally different from all that preceded it and during which the basis of society was more completely altered and the economic and political structure more fundamentally revolutionized than in all the preceding centuries of civilization put together.

Of the ten decades which may be roughly stated to cover this notable period of development, not one has failed to contribute its quota toward the sum of great inventive achievements. Each and every decade has seen the origin of some transcendent act for the advancement of material civilization.

The ten years most fraught with achievement up to the invention of the telephone, was the 1840-1850 period, during which the reaper, vulcanization of rubber, sewing machine, and telegraph were perfected. These inventions, by far the most notable of the decade, were all American and marked the culmination of Yankee ingenuity, and it is safe to assert that no other people in any equal short span of time can point to a record of accomplishments so marvelous and so revolutionizing, industrially and socially.

The decade beginning with 1870 was also notable—the telephone, the dynamo, and the arc lamp appeared and gave the first indications of the coming part electricity was to play in the affairs of mankind.

But the ten years beginning with 1880 saw an outburst of inventive activity that dwarfed all similar periods in the history of invention. It seemed that the discoveries in things electrical in the last three or four years of the previous decade was the signal for the pent-up genius of the world to let loose.

The trolley car, which has changed the face of urban civilization; the incandescent light with its more powerful and healthier glow and more adaptable use; the automobile, the most distinctive feature of our time; the typewriter, the most necessitous instrument in modern business; the skyscraper, the delineator of the new skyline of American business centers; and the cash-register, that ubiquitous instrument and first aid to honesty—to pick out the most obvious of the innovations that proclaim the age—all of these came into being or were first whipped into shape in the ten pregnant years beginning with 1880.

Before 1880 electricity was sparingly used—the first central station for arc lighting had just been established in 1879. Its recognition as a source of energy for universal lighting, for propulsion, for power, and for heating—for all the large and vital uses it could be put to—was a matter of speculation, and not one of expectedly near realization. No one, even of the wildest imaginings, could have dreamed of the transformation so close to hand. But before this census period closed the electric incandescent lamp was incontestably established, the trolley car was successfully introduced, the central station for power distribution and the polyphase motor for stationary work began to show its revolutionizing possibilities, and the first electric furnace was put into successful commercial operation.

All the big problems that were involved in putting into service in such large ways of this new and mighty servant were first confronted and solved in this particular decade. In the 80's the generation, transmission, and utilization of current—the dynamo, the transformer, and motor—were all made practical propositions on a large and commercial scale for the first time. The trolley car, which drastically changed the aspects of things urban and suburban, brought the country to the city and spilled the city into the country, increased land values by the billions; and the incandescent lamp, which inaugurated clean and safe illumination, introduced the central station power house and inspired the first great innovations in generation and utilization of electric current; the transformer, that extremely simple but supreme instrument for making serviceable the alternating current—the most easily generated and transmittable form of electrical energy; and the induction motor, the eventual driver of most of our machinery—all these peaks in electrical progress were made in the same decade.

The most fundamental of all operations are performed in the furnace. The profoundest changes of nature were caused by heat and the basic processes of industry are carried under high temperature conditions. Except a new source of energy, it is difficult to conceive a new utility of more potency than a novel type of furnace. For the first time in all history, a high furnace heat was attained through means not involving combustion, when the electric furnace was perfected in the latter part of the decade. With the advent of this utility, possibilities of heat application were opened up that shamed even the dreams of alchemy. There is no burning, no smoke or foul gases—resultants of combustion. The heat is clean, controllable, and extremely high, with the result that it is revolutionizing high temperature operations in multitudinous directions, and the changes in steel and alloy making and in electro-chemical processes are already profound.

The steam turbine, which is supplanting the reciprocating engine; the gasoline engine, which made possible the motorboat, automobile and aeroplane; the automobile itself; the Mergenthaler typesetter and caster; the cyanide process, which vies in importance with the Bessemer method of making steel and the vulcanization of rubber; and electric welding—all of these truly epoch-making inventions first saw the light of day in this census period.

The Harvey process for hardening armor plate was invented in 1888; smokeless powder a few years earlier; the wax phonographic record, which made the phonograph a practical proposition, came out about the same time; Westinghouse's quick-acting brake, which only failed to be considered a pioneer invention of the first order by a five to four vote of the Supreme Court, was another notable addition to the decade; the transparent film, which foreshadowed the moving picture; and the pneumatic tire, which helped to popularize the bicycle and automobile, were prominent contributions of these pregnant ten years.

The half-tone process, the most notable advance in the reproductive arts since lithography was established; the Janney type car-coupler, the greatest life-saver ever invented; and the centrifugal creamer, which has saved the farmers of the civilized world hundreds of millions of dollars, were all commercially established during this period.

The Super-battle-cruiser

THAT the leading naval power in the world is satisfied that the battle-cruiser has fully vindicated the claims of those who were responsible for its introduction, is proved by the fact that the British Admiralty is completing four ships of this type in which the elements of speed and gun-fire will be carried such a great step in advance as to place the new ships in a class by themselves. Indeed, if there be such a vessel as a super-dreadnought, it is certain that these ships should be termed super-battle-cruisers.

We are reliably informed that this group of ships is being rushed to completion, and that the extreme features which they will embody in the way of gun-fire and high speed were decided upon as the result of experience gained during the present war. They are to mount the 15-inch gun, and they are designed to steam at a sustained sea speed of 32 knots. The armor protection is to be of moderate thickness, necessarily. Now here we have a ship which will have the widest possible range of usefulness outside of the line-of-battle engagement between heavily armored dreadnoughts. Thus, if the German battle-cruisers should attempt another raid on the English coast, the 32-knot ships, if they get in touch, could easily overtake and sink them. They could catch and sink the fastest of the modern scouts; and in any but the calmest weather could round up and dispose of a whole fleet of torpedo boat destroyers, whatever their speed might be. Also, if their own fleet were pursuing a battleship column, they could overtake and concentrate on the rearmost ships, thereby forcing the enemy to accept engagement—unless, indeed, the enemy admiral should leave his rear to shift for itself, as was done by the German battle-cruisers when they left the "Bluecher" to its fate in the North Sea battle.

The persistent cutting down by Congress of the programmes of battleship construction submitted by our Navy General Board, is responsible for the fact that to-day the United States Navy does not include a single ship of the battle-cruiser type. If we possessed the battleship strength which the General Board considers necessary for the safety of the country, they would recommend the creation of a battle-cruiser fleet—indeed, we should now have several of these most necessary ships under construction.

Seventy Years of Invention

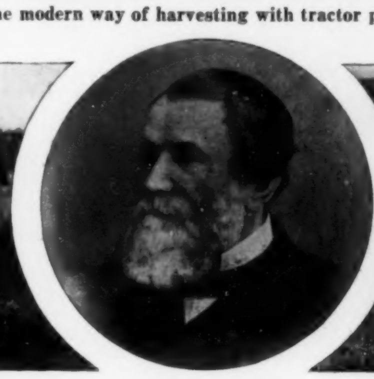
A Record of Progress, Decade by Decade

The old cradle.

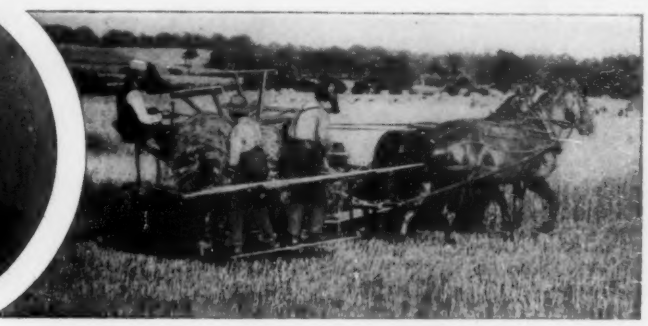
The modern way of harvesting with tractor power.

Used for forty centuries.

The first McCormick self-rake reaper.



Cyrus H. McCormick.



The Marsh harvester.

1845-1855

TELEGRAPHY was the only practical application of electricity in the early 40's and, for that matter, for several decades following. Hardly had Morse's experimental line between Washington and Baltimore been successfully opened (1844) when literally dozens of inventors on both sides of the Atlantic applied themselves to the improvement of telegraphic communication. The article on communication appearing elsewhere in this issue reviews the art with such fullness that it need not be dwelt upon here.

Some Early Electrical Devices.

But, although the telegraph was the great electrical invention of the decade, experimenters were seeking to find new applications for electricity. Thus, in 1848 Foucault and DuBoscq constructed the first practical arc lamp, having a clockwork to adjust the distance between the carbon electrodes automatically. Charles Wheatstone and W. F. Cooke (1845) substituted electromagnets for permanent magnets in electromagnetic machines and thus brought electrical engineering nearer the modern dynamo.

There were even thoughts of the electric railway; for in 1851 the versatile and daring Moses G. Farmer of Newport made rather unsuccessful experiments with an electric railway, in which the current, derived from a battery, was sent through the rails. In 1851 Thomas Hall of Boston succeeded in driving a vehicle with a magnetic machine supplied from a stationary battery, an early attempt at electric automobiling. In 1854 M. Davidson also made experiments with an electric automobile.

Although Sir Humphry Davy had used the electric arc for the production of sodium, the modern electric furnace really begins with César Mansuète Despretz, who in 1849 conceived the idea of employing a carbon retort, the negative pole of the arc consisting of a carbon rod and the retort itself constituting the positive pole.

Progress in Automatic Machines.

Of far more importance, however, were the advances in mechanical invention. The idea of rolling window or mirror glass was proposed by Henry Bessemer. He poured the glass between two spaced hollow rollers cooled by circulating water. Picard and P. Simon revived the idea in 1887 and 1888. In 1846 Farthing endeavored to substitute compressed air for lungs in glass blowing. His method of glass blowing was much used by the end of the 70's.

In 1846 Richard Marsh Hoe made valuable contributions to printing machinery. He developed the type revolving press of the period, in which a single form of type was carried beneath four, six, eight, or ten printing cylinders and used to print upon a sheet borne by each. This press became the standard of the world. Later Stephen Tucker, an employee of Hoe's, converted this into the perfecting press; that is, into one that printed on both sides of the sheet. Eventually he adapted his machine to print upon a web or endless sheet of paper.

In this article we have endeavored to record the principal inventions which during the last seventy years have contributed markedly to industrial progress. The record is necessarily incomplete; for in the limited space at our disposal, we could not do more than indicate the most important achievements. We have confined ourselves almost entirely to mechanical inventions, not that the work done in industrial chemistry and pure science falls without the scope of the SCIENTIFIC AMERICAN, *but simply because the* SCIENTIFIC AMERICAN *has been very closely identified with invention.*

In order to avoid unnecessary duplication, the facts recorded in special articles appearing elsewhere in this issue have not always been incorporated in the following. But the leading achievements in the main arts have been repeated wherever it seemed desirable to keep the record as complete as possible. Very few references have been made to military inventions. It was felt that this should be a record of industry and peace.

We wish here to acknowledge the great assistance which has been given to us by many of the leading manufacturing firms, inventors, and engineers throughout the country. Without their generous help it would have been difficult, if not impossible, to reveal the beginnings of many an important industry.—EDITOR.

An Early Dirigible Airship.

The modern dirigible had its origin in this decade, for Henry Giffard built a cigar-shaped dirigible airship in 1852. It had a steam-driven propeller and actually traveled against the wind. In 1855 Giffard built a larger ship (4,500 cubic meters capacity).

Of the improvements in civil engineering that deserve to be noted, it must be mentioned that in 1846 the French engineer Fauvelle invented the process of boring with a continuous stream of water and succeeded in boring a 170-meter hole in twenty-three days, by forcing water under high pressure into a hollow boring tool. His process is the basis of the boring pump devised in 1860 by Chanoit and Catelineau.

In 1852 Merriweather, a California gold miner, invented the hydraulic system of mining gold.

The modern bicycle sems to have had its origin in 1854. P. H. Fischer, a mechanic of Schweinfurt, Germany, added pedal cranks to the velocipede. Quite independently Ernest Michaux hit upon the same idea in 1855. Rubber tires seem to have been first used in 1865 by M. Thévanon of Lyons.

Improvements in Steam Engineering.

In steam engineering the most notable achievement was undoubtedly George H. Corliss's invention, in 1848, of his famous valve gear, patented in 1849.

The first steam boiler with horizontal iron tubes was constructed in 1855 by Julien Belleville. Wilcox built his first steam water-tube boiler with inclined water tubes in the same year, his construction being later very much improved by Babcock & Wilcox.

In the year 1840 Henry R. Worthington conceived the idea of applying steam to the propulsion of canal boats. Among other difficulties encountered was that of supplying his boiler with water, while the boat was passing through the locks, the engine, and consequently its attached pump (the only type in use at that period), being at rest. The result of his investigations was the first independent single direct-action boiler steam pump ever constructed. This pump was in successful operation for over thirty years. Worthington began the manufacture of these pumps in 1845.

In this decade belongs the beginning of the modern high explosive industry; for in 1845 Christian Friedrich Schoenbein discovered nitrocellulose or guncotton.

The Bessemer Process Invented.

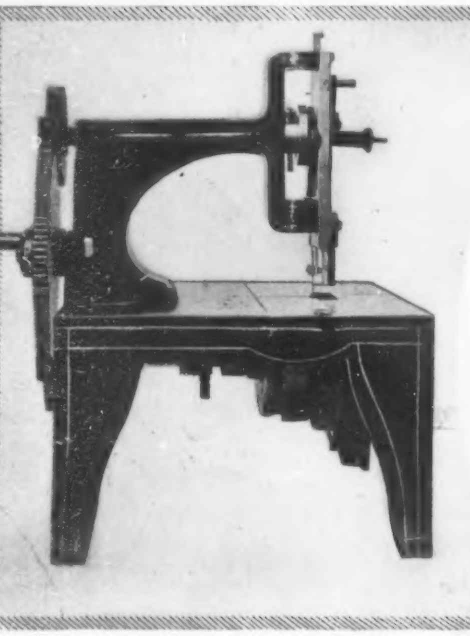
Industrially, by far the most important invention of the decade was the Bessemer process of making steel. It was in 1855 that Henry Bessemer invented his famous process for the direct conversion of molten cast iron into steel by blowing air into the molten mass. As a result the steel and iron industry was liberated from the dominance of hand labor, and the process of making steel was at once shortened from one and one half days to twenty minutes.

The Men Who Invented the Sewing Machine.

On September 10, 1846, Elias Howe received a patent for his epoch-making sewing machine. The features that made Howe's machine a success were a needle with the eye at the point, a shuttle operating beneath the cloth to form the lock sitch, and an automatic feed.

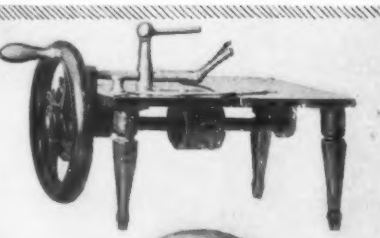
Next to Howe, the name of Allen B. Wilson claims notice as the inventor who has done the most to give us the present perfected sewing machine. To him we are indebted for those two most ingenious and beautiful pieces of mechanism; the rotating hook and the four-motion feed. He claimed to have conceived the idea of a sewing machine in 1847. His first machine was built during the spring of 1849, while he was employed in Pittsfield, Mass., as a cabinet maker. In the same year he built a second and better machine, and "up to this time," he says, "I had never seen or heard of a sewing machine other than my own." He took out his first patent on November 12th, 1850. This machine Allen B. Wilson brought to New York in order that he could exhibit it to the Editor of the SCIENTIFIC AMERICAN and have it described in that publication.

In 1851 Wilson patented his famous rotating hook, which performs the functions of a shuttle by seizing the upper thread and throwing its loop over a circular bobbin containing the under thread. This simplified the construction of the machine by getting rid of the reciprocating motion of the ordinary shuttle, and contributed to make a light and silent running machine, eminently adapted to domestic use.



The original Singer sewing machine.

Howe.



The original Howe sewing machine.

In 1852 Mr. Wilson patented his four-motion feed, which, in combination with a spring presser foot, may be said to form the basis of all modern feeding mechanisms.

In 1851 W. O. Grover and W. E. Baker patented a machine which made the "Grover & Baker chain stitch."

In 1859 Gibbs, a Virginia farmer, saw in the Scientific American a picture of a sewing machine. The working of the apparatus was very plain down to the moment when the needle perforates the cloth, and he fell into the habit of musing upon the course of events after the point of the needle was lost to view. The result of his cogitations, aided by infinite whittling, was the ingenious little revolving hook, which constitutes the peculiarity of the Willcox & Gibbs machine.

Patent No. 8294, of August 12th, 1851, introduced one of the most useful machines. Isaac Merritt Singer, strolling player, theater manager, inventor, and millionaire, brought into the business a new machine and novel methods of exploitation, which gave a powerful impulse to the youthful industry. The Singer improvements met the demand of the tailoring and leather industries for a heavier and more powerful machine. The novelties consisted in the circular feed wheel below the cloth plate, which had a serrated periphery projecting slightly above the plate, and was fed by a rock shaft and pawl; a thread controller; and the use of gear wheels and shafting to transmit the power from the hand wheel to the two countershafts for working the vertical needle and the shuttle. Singer was also the first to introduce foot power in place of the hand-driven crank wheel.

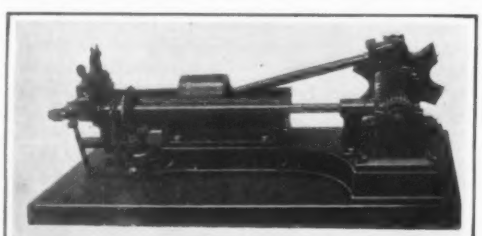
John Brooks Nichols, a Lynn shoemaker, about the year 1851 adapted the Howe sewing machine to sew the uppers of shoes, the first important step in the application of machinery to shoemaking. The first machine was introduced in Lynn in 1852 by John Wooldredge.

The Passenger Elevator.

The first elevators were undoubtedly devised for the handling of heavy goods, and although the solid platform, hoisted by a hand-power windlass, was a great improvement over the original block and fall of the sailor, it was not intended that these mechanisms should be used to carry human beings. When, however, steam power had come into common use, and buildings had become taller, it was but natural not only that power should be applied to the operation of elevators, but that the extension of the use of elevators to the carrying of passengers should be suggested by the improvement. All of these changes were extremely gradual, the first power elevators being used indiscriminately for both freight and passengers; but it may be said that the first power elevator was installed in 1852, by Elisha Graves Otis; and a few years later he exhibited at the Crystal Palace, in New York, the first elevator with a safety device to prevent the car from falling when the cable broke. The first exclusive passenger elevator operated by steam was installed in the Fifth Avenue Hotel in 1859 by Otis Tufts.

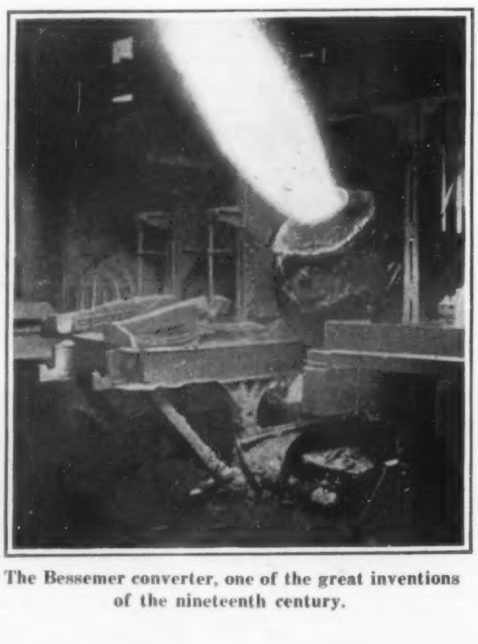
The Beginning of the Typewriter.

Many acute minds were working before the first writing machine appeared. The efforts of inventors to produce a telegraphic printing machine gave impetus to the idea of a writing machine, although the first attempt to produce a typewriter is found in the records of the British Patent Office as far back as 1714. A really competent complete machine did not appear until 1843, when Charles Thurber of Worcester, Mass., patented a slow typewriter. The model was interesting as effecting the letter spacing by longitudinal motion of a platen—a principle which is a feature of all modern machines. Fairbanks in 1848 designed a machine for printing colors on cloth. It was impracticable.



Model of the Otto gas engine in the National Museum, Washington, D. C.

In 1847 Dr. Francis, a wealthy physician of New York, patented a typewriter, in which a motion similar to that of a piano hammer was employed to throw up the types, which were arranged in a circle to a common center. It was bulky and intricate, and although capable of good work was too costly for a commercial venture. This machine contained many of the salient features of the typewriter of to-day, such as the carriage traveling from side to side over the type basket, a large bell to indicate the end of the line, blank key for spaces.



The Bessemer converter, one of the great inventions of the nineteenth century.

The Reaper and the Harvester.

In 1831, Cyrus H. McCormick of Virginia built the first practical grain harvesting machine. But it was not until 1845, the year in which the Scientific American was established, that the reaper was really introduced. It contained the essential elements that have been found in every grain harvester that has proved a success from that day to this. The first machine had a main wheel frame, from which projected to the side a platform containing a cutter bar, having fingers through which reciprocated a knife driven by a crank; upon the outer end of the platform was a divider projecting ahead of the platform to separate the grain to be cut from that to be left standing; a reel was positioned above the platform to hold the grain against the reciprocating knife, and to throw it back upon the platform, and the machine was drawn by a team walking at the side of the grain. The motive power was oxen or horses, hitched either at the side and front, or behind, and the grain, forced to the sickle by the reel, was cut and dropped to the platform. A man, walking alongside of the platform, removed the grain with a rake.

The great difficulty encountered by the predecessors of McCormick was the sickle. Many different devices were tried, but nothing equaled the reciprocating knife. The next improvement on the first practical reaper was McCormick's addition of a seat for the man who raked the grain. Several years later a self-rake was added, which eliminated the extra man. The reaper to-day is built largely along these lines.

The next progressive step in the development of the reaping machine was the application of an automatic mechanism to rake the grain from the platform to the ground. This work had, up to this time, been done by a man riding on the machine. In 1849 Jacob J. and Henry F. Mann of Indiana patented a machine having a series of endless bands for carrying the grain, after it had been cut and reeled upon these bands, to the side of the machine, where it accumulated in a receptacle until a sufficient amount had been gathered to form a bundle, when the operator dumped the receptacle, leaving the gavel upon the ground.

In 1850 Homer Atkins of Illinois invented a device for giving a reciprocating, intermittent motion to a rake, in order to deposit the grain upon the ground, after it had been cut and reeled upon the platform. This machine marks the beginning of an era of self-raking reapers, that continued to be supplied to the market for twenty years. In the summer of 1850, Augustus Adams and J. T. Gifford, of Elgin, Ill., built probably the first hand binding harvesting machine. It was a machine of the same type as the Mann machine of 1849, but it had in place of the receptacle into which the cut grain fell as it left the traveling apron that conveyed it to the side, a platform upon which men were carried through the field, and upon which the grain fell from the endless apron, where it was bound by men carried upon the machine. This is probably the earliest example of a machine which afterward came into extended use under the name of haul binding harvester.

In 1858 C. W. and W. W. Marsh of Illinois invented their harvester. The grain after it had been cut and

deposited upon an endless apron was carried to one side of the machine to men riding upon the machine, who bound this grain into bundles. It should be remembered that the self-raking reaper was the machine in general use up to this time, and men did the binding, walking from gavel to gavel. The Marsh machine is interesting not only as marking a progressive step in the development of harvesting machines, but as furnishing the machine to which the automatic binder was successfully attached.

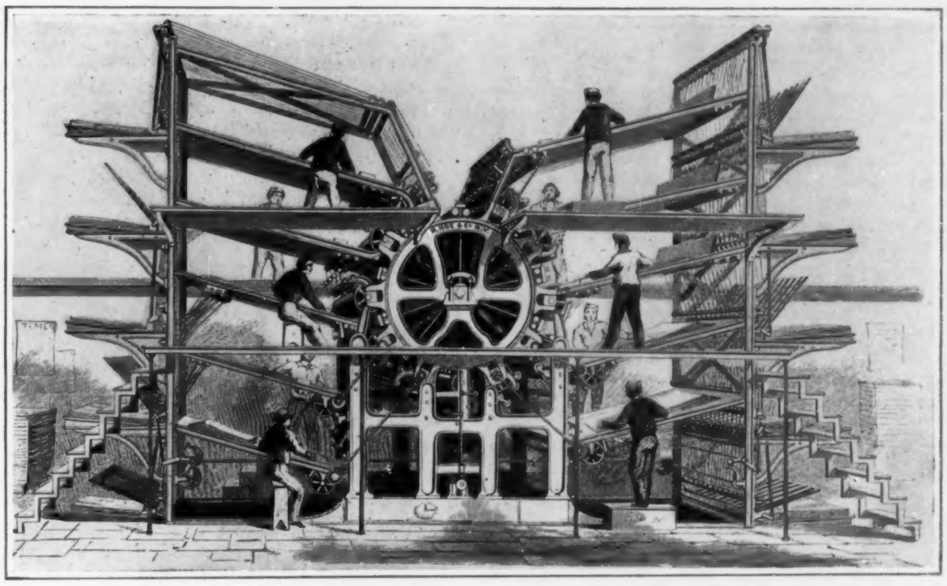
The commercial value of all the branches of industry that owe their existence and prosperity to McCormick's invention of the reaper is beyond conjecture. The value of farms has increased from one million dollars in 1800 to twenty billions in 1906—more than four times the value of all the manufacturing enterprises in this country.

The yield of the crops is so enormous that not enough men could be gotten into the fields to harvest them if the reaping hook were the harvester.

1855-1865

The decade is notable for the important work done in laying the foundation of modern electrical engineering.

The first direct current motor was built in 1860 by the Italian physicist Antonio Pacinotti. His machine consisted broadly of an iron ring, suitably wound, which rotated between the poles of a horseshoe electromagnet supplied with current from a battery. In the same year Pacinotti invented the commutator. Pacinotti did nothing with his inventions, important as they were. The world had to wait for Gramme to reinvent them.



The Hoe revolving press of the fifties. From a contemporary engraving.

Alfred E. Beach's hydraulic shield, first practically used in tunneling under New York, 1869.

Gaston Planté invented his "accumulator" or storage battery, consisting of two lead plates immersed in dilute sulphuric acid. When the element was charged the positive electrode became covered with a layer of superoxide of lead. When this plate was used as a cathode a powerful current was obtained, the super-oxide decomposing again.

In 1859 Moses G. Farmer of Newport illuminated his house with forty-two platinum incandescent lamps, one of the earliest instances of the use of electric lighting.

The idea of separating iron magnetically goes back to 1792, when William Fullerton took out a patent on an apparatus. Electromagnets were proposed by and used experimentally by Arthur Wall (1847) and Chenot (1854). A great step in advance was taken in 1858 when Quintino Sella used an electromagnetic machine for the preparation of ore. He seems to have used the device practically in obtaining iron free from copper and sulphur and was thus enabled to utilize ores for which there had been no practical use. Edison made vast improvements along the same lines many years later.

Improvements in Metallurgy.

The first modern coke oven of the by-product recovery type was built in 1856 by Carvès at Lebrun, Commentry. After the oven had been improved by Carves and Knab in collaboration, eighty-eight ovens were built in 1862 at the Usine du Marais in Terrenoire.

The principle of centrifugal casting in the production of iron and steel, although proposed as early as 1859, was practically carried out by Henry Bessemer in 1856. In order to avoid blowholes, the molten mass was poured into a circular closed mold having a vertical axis which could be turned with a speed of 2,000 revolutions a minute. A similar process of producing wagon tires was disclosed by Withley and Bower in 1864.

The first modern hydraulic press was built in 1858 by Robinson and Gotham for iron works, but hydraulic press forging was substituted for the hammer in 1861 by John Haswell, whose first press had an effective pressure of 16,000 hundredweight. Haswell's press was improved by Reiner Daelen in 1865 by applying steam pressure directly, thus dispensing with a pump and an accumulator.

The idea of using slag for the making of Portland cement was suggested in 1862 by Eugen Langen, who noticed that the blast furnace slag of an iron foundry had hydraulic properties when granulated. Langen's suggestion was practically carried out in 1865 by Fritz Lürman, who made artificial building stone of granulated slag and limestone under pressure.

Most important in its general industrial effect was the invention of the regenerative gas furnace by Friedrich and William Siemens in 1856. Edward Cooper applied Siemens's regenerative principle to blast furnaces in 1859, his ideas being readily accepted in the Cleveland district.

Colonel Drake Strikes Oil.

On August 28th, 1859, G. L. Drake, while driving an artesian well, struck oil. Although petroleum had been known even in ancient times, Drake's was the first oil well. Ever since his time petroleum has been an article of commerce. The idea of the pipe line suggested itself as early as 1860 to J. D. Karns and Hutchinson. Their attempts at piping oil were not very successful. The first really successful pipe line was laid by Samuel Van Syckle in 1865 between Pithole and Miller's Farm. Another pipe line was built by Henry Harley at the end of the year and the success of the principle was demonstrated by him.

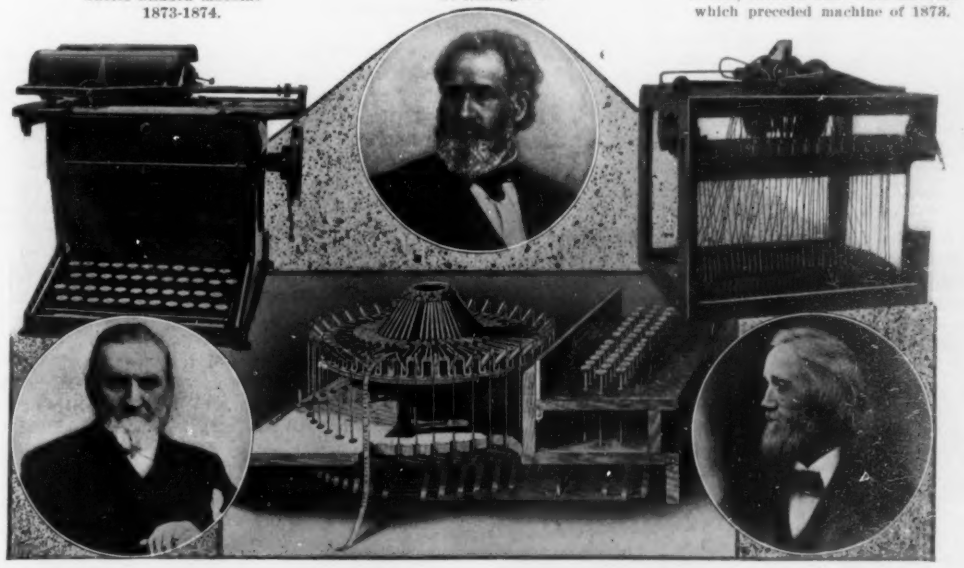
The Beginning of Modern Refrigeration.

The modern ammonia absorption ice machine was devised in 1860 by the French engineer, F. P. E. Carré. In this machine water was brought to the freezing point by the rapid evaporation of condensed ammonia. Improved by Reis (1870) and Koch and Haberland (1871), this machine held its own until the compression apparatus was brought to a high state of efficiency. A closed cold air or refrigerating machine was built in 1862 by A. C. Kirck. This machine used the same air over and over again and exerted its cooling effect indirectly through tubular walls which are built in the chamber or fluid to be cooled.

How the Pump Was Improved.

Finding that his early pump lacked smoothness in operation, Worthington developed the duplex pump, which he patented in 1859. Another inventor who did much to improve the pump was George F. Blake. In 1862 he installed and operated his first single direct-

Sholes-Glidden machine 1873-1874. P. Remington. Sholes, Glidden and Soulé machine which preceded machine of 1873.



James Densmore. The typewriter of A. E. Beach (1856). C. L. Sholes.

Ancestors of the modern typewriter.

action pump, which was immediately successful, and with slight modifications was patented on April 12th, 1864. In the same period belongs the development of the Knowles pump.

In 1862 attention was drawn to the need of better protection against fire in Lockport, N. Y., and in 1863 Holly constructed the first water-works plant, consisting of a rotary pump, turbine water wheel, about one mile of water main and twelve fire hydrants, under what has since become known throughout the world as the Holly system of water supply and fire protection for cities and villages.

In steam engineering we must note that in 1858 John Elder combined the compound steam engine with the surface condenser, and thus devised a type of double-expansion compound engine, which has markedly influenced the development of marine engineering.

In 1860 Lenoir patented his historic gas engine, in which he actually used electrical ignition.

The Harvester is Developed.

Sylvanus D. Locke of Janesville, Wis., during these years was working upon a wire binder. He took out many patents, and in 1873, after associating himself with Walter A. Wood, built and sold probably the first automatic self-binding harvester that was ever put upon the market. The different builders of reaping machines were at work at this time perfecting automatic binders which they were attaching to harvesters of the Marsh type, by removing the platform upon which the men stood and placing the automatic binder so as to receive the grain as it is delivered from the elevator of the harvester. The use of wire, however, as a binding material met with opposition, and the inventors turned their attention to perfecting an attachment that would bind with cord; and to Marquis L. Gorham of Rockford, Ill., who built a successful cord binder and had it at work in the harvest field in 1874, must be given the credit of producing the first successful automatic self-sizing binder. It bound with cord and produced bundles of the same size. It was like McCormick's reaper a machine that contained the essential elements that have been found in every grain binder since its time.

In 1879 John F. Appleby took out a patent on a machine upon which he had been working for about four years, which in the arrangement of the devices was an improvement to that of Gorham. It, however, contained the principles of the Gorham machine, which he had seen in operation in the field before he began to work upon his twine binder. The modern twine binder is, in the form of its devices and the arrangement of its parts, built upon the Gorham plan, as improved by Appleby.

A few years prior to 1859, P. H. and F. M. Root conceived the idea of developing a water wheel built on the principle of the present two-lobe positive pressure blower. The machine was constructed to be used as a water wheel. It was installed and tested out, but as the rotating parts were lagged with wood, the wood swelled. The machine was taken out and brought to a machine shop in Connersville and the impellers were trimmed off with an ordinary plane. While they were running the machine to see if the clearances were properly made, the operator of a local foundry was standing by and observed that it was discharging a blast of air. This foundryman afterward became the foreman of Root brothers' foundry. This suggested to the brothers the idea of constructing a positive pressure blower for foundry work—the inception of the positive pressure blower.

The Solvay Soda Process and Other Interesting Processes.

The decade brought forth the Solvay soda process, one of the great achievements of industrial chemistry. After the experimental ammonia-soda factory of Dyar and Hemming (1838) had proven more or less a failure, as well as the experiments of Deacon and Gaskell (1854) and of Schlösing and Rolland (1855) in Tetaux, the Belgian chemist and engineer, Ernest Solvay, took up the idea again, invented the mechanical appliances for carrying out the reaction, and succeeded in placing the ammonia-soda process on a commercial par with the LeBlanc soda process (1861).

Printing Presses and Textile Machinery.

The type revolver printing press was in general use until Bullock introduced his stereotype perfecting press in this decade. This cut the sheets from a web before they went to the printing cylinders. Between 1862 and 1864 Andrew Campbell put out the first cheap cylinder press, the "Country Campbell," by means of which small newspapers were liberated from the Washington hand press. Campbell then built his two-revolution printing machine (1865-1870), which has since become the standard press throughout the world.

In 1857 Snell and Bartlett patented their mechanical let-off for warps, an important improvement in textile machinery. The principle of this warp let-off was to actuate the large warp beam containing the warps at the rear of the loom by a ratchet and pawl connection with the oscillating lay, the movement of this ratchet and pawl-actuating mechanism being controlled by the tension of the warps. This form of let-off, with little improvement, was applied to cotton looms up to 1888.

It was in this decade that George Pullman introduced the Pullman car. He improved it rapidly year by year. In 1867 he devised the combined drawing-room car, which could be converted into a sleeper at night.

An Early Submarine.

Bushnell in 1775 built the first practical submarine boat, and Fulton in 1801 employed the usual vertical rudder and a horizontal rudder. Although Bauer, a Bavarian, constructed a submarine vessel in 1850, no substantial advance was made until Bourgeois and Brun completed "Le Plongeur" in 1864. Her novel feature consisted in her compressed air system for underwater propulsion, which worked satisfactorily; but her submerged control was bad. She had an additional boat, carried in the superstructure, into which her crew could enter through double hatches, then release this small boat and ascend to the surface in case of an emergency.

Shoe Machines Appear.

The year 1858 marks the beginning of the wonderful modern shoe machine industry, for then it was that Lyman R. Blake invented a machine which sewed the soles of shoes to the uppers. The machine was financed and improved by Gordon McKay and became known as the McKay sewing machine. The first machines were introduced in the factory of William Porter & Sons, Lynn, Mass., in 1861 or 1862 and were run by foot power. This invention, probably more than any other, is responsible for revolutionizing the manufacture of shoes. In 1862 Auguste Destouy invented a machine with a curved needle to sew turn shoes, which was improved by Daniel Mills in 1869. This machine was adapted by Charles Goodyear to the sewing of welts. Goodyear patented his machine in 1871 and 1875. These patents were the foundation of the famous Goodyear welt system of manufacturing shoes.

How the Modern Typewriter Was Evolved.

A marked advance in typewriting machines was made in 1856 by Mr. Alfred Ely Beach, Editor of the Scientific American and one of the founders of Munn & Co. This machine was primarily intended for the printing of embossed letters for the blind, but could also be adapted to the general uses of the typewriter. It employed pairs of dies to imprint characters on a narrow ribbon of paper. These were ranged about a circle, each pair swinging to a common center, much in the manner of the modern typewriter.

During the winter of 1866-1867 C. Latham Sholes, a printer and editor by trade, and Samuel W. Soulé, also a printer, inventor and farmer, were engaged together in developing a machine for serially numbering the pages of blankbooks. At the shop where they were having their work done Carlos Glidden, the son of a successful ironmonger of Ohio, was also engaged in developing a mechanical "spader" to be used instead of a plow. Glidden became interested in Sholes's machine and suggested the idea of devising a mechanism which would not only write numbers, but also letters and words. In the following year a copy of the Scientific American fell into the hands of Mr. Glidden. It described a machine called the pterotype (winged type), invented by John Pratt, which was designed to do just what Glidden had suggested. This article was brought to the attention of Sholes. Glidden, Soulé, and Sholes eventually formed a combination to develop a practical machine. Glidden contributed suggestions; the first crude model was largely the work of Soulé, who suggested the pivoted types set in a circle and other minor details; Sholes contributed the letter-spacing device. By September of that year the first machine had been made. It was a success in so far as it was able to write accurately and with fair rapidity; but it was not yet a commercial machine. One of the letters written on the machine reached James Densmore of Meadville, Pa. He was attracted to the new enterprise and purchased an interest in it. He did not see the typewriter until March, 1868. He urged further improvements, pointing out many defects. Soulé and Glidden dropped out of the enterprise and left it entirely to Sholes and Densmore. Inspired by Densmore, Sholes made model after model. At last by 1873 the machine had been developed so far that it was felt it could be manufactured, and with that end in view Densmore came in 1873 to the gun factory of E. Remington & Sons of Ilion, N. Y. At the factory of the Remingtons the machine was further developed and was finally placed upon the market about the middle of 1874. From that time on the typewriter began to work its way into every business house, until now very few business letters are written by pen.

1865-1875

Modern electrical engineering is placed on a sure footing in this decade; for we find not only the dynamo and the motor vastly improved, but new applications of the electrical current.

In 1869 Z. T. Gramme combined the Pacinotti ring armature, which he had reinvented quite ignorant of the Italian's pioneer work, with the Siemens dynamo. Hence he constructed what is considered to be the first dynamo-electric machine for delivering a continuous direct current. Who first discovered the modern dynamo it is hard to determine. Certainly the correct principle of the dynamo was set forth by Werner von Siemens. In 1877 he found that the mass, form and magnetic property of the magnetic parts reinforced one another to a certain maximum when properly designed, and built a dynamo-electric machine in which he used a double T armature. A fortnight later Charles Wheatstone published the principle of the dynamo.

Wheatstone and Cooke had made experiments in 1845 with a magneto machine in which electromagnets were substituted for the previously used horseshoe magnets. The same idea was practically applied by Henry Wilde in 1867 to construct an alternating current machine. Between two rows of electromagnets of opposite polarity a corresponding number of armature spools with iron coils rotated.

H. Fontaine and Z. T. Gramme exhibited the principle of power transmission from an electric generator to an electric motor at the Viennese Exposition in 1873.

In telegraphing the decade is memorable for the invention by Edison of his duplex system and his quadruplex system, and for the laying of the first cable (1866) from Ireland to Newfoundland through the efforts of Cyrus W. Field, John Pender and James Anderson.

Some Mechanical Marvels of the Sixties and Seventies.

Mechanical marvels in their day were machines to which we have become so accustomed that they are accepted as a matter of course. It was considered remarkable, and so it was, when Jacob Reese, an American inventor, in 1875 built a machine for cutting iron and steel with rapidly rotating disks of soft iron. The technical press of 1872 commented with admiration on A. Brandon's file-making machine, which, in imitation of hand labor, applied chisel and hammer separately, but which, however, could be used only for making flat files. It was improved by Maurice Mondon of London, in 1874, so that convex filing surfaces could be made. The modern machine, however, was invented by Disston of Philadelphia. The idea of rolling instead of forging files was carried out in 1864 by B. H. Dodge, who constructed a machine for that purpose.

Most wonderful of all was the rotary knitting machine, built by Lamb of Valparaiso, Indiana, in 1866. This machine was afterward improved by Dubied and Watteville. It makes a stocking without any seam whatever.

Benjamin C. Tilghman invented the sand blast in 1871 for producing mat glass. His invention was afterward introduced into the iron and stone industries.

Tilghman is also to be credited with the invention of chemical wood pulp, although ground wood pulp had been known since 1840, when Friedrich Gottlob Keller took out letters patent in Germany for a wood pulp grinding machine; the process of manufacture was not developed and applied for producing paper suitable for newspapers until a much later date. It began to be used commercially about the time of the discovery by Benjamin C. Tilghman of the disintegrating action of sulphurous acid upon wood, which resulted in the invention of chemical wood pulp (1866). After Tilghman in America had pointed the way, George Fry and his collaborator, Ekman, developed at Bergvick, Sweden, the process of separating the cellulose of wood by boiling it under pressure in an aqueous solution of sulphur dioxide in which magnesium sulphite was dissolved. The Ekman process, which was first worked in the liquor used for cooking wool, consisted of an acid solution of magnesium sulphite, the magnesia being obtained by burning magnesite imported from Greece.

Advances in Metallurgy.

In 1862 Joseph Moore of San Francisco brought out the California stamp mill, which became of great importance in mining. The dry concentrator in which air is employed for the separation of minerals was introduced in 1868 by Stephen R. Krom. Another improvement which meant much to the mining industry was Dingey's mineral mill (1872) consisting of a slowly revolving horizontal slotted plate over which four notched disks rotated in the opposite direction. This machine proved twice as efficient as the stamp mill.

George Bedson of Manchester in 1867 invented a continuous wire rolling mill. He was the first to roll out metal bars weighing one hundred pounds into wire at the rate of eleven tons a day. He arranged his rollers in alternate vertical and horizontal pairs.

Westinghouse and the Air Brake.

Railroading received a great impetus by George Westinghouse's invention of the air brake. It was in 1875 that he brought out this the first successful invention of the kind and one which made high speed railway travel possible. Year by year Westinghouse continued to improve the brake, giving it his personal attention until far into the twentieth century.

Another railway development of importance was the advent of the automatic block signal system (banjo signal) invented in 1871 by Thomas J. Hall, and soon widely adopted in the United States of America.

An invention which attracted but little attention at the time, but which was the beginning of the reinforced concrete industry, appeared in 1867. Then it was that José Monier patented a method of making flower pots out of cement with a reinforcement of iron netting. This seems to be the first instance of the utilization of reinforced concrete. In additional patents, taken out in 1868, 1873, and 1875, Monier extended the principle to bridges, staircases, railway sleepers, and the like, thereby proving that he was keenly alive to the possibilities of his discovery.

The first great modern vacuum ice machine (the principle was proposed as early as 1810) was exhibited by Edward Carré at the Paris Exposition of 1867. In this machine water was used as the vaporizing fluid and concentrated sulphuric acid as the absorbing fluid.

In 1873 Lowe and White invented the modern water gas process. They blew steam into a layer of red hot coke and carbureted the resultant gas with oil. Another improvement in the art of illumination was that of C. Tessié du Motay, who invented the zircon light in 1867, in which a pencil of zircon was heated to incandescence in a gas blowpipe. Clammond, in 18[illegible]2, hit upon the idea of bringing magnesia to incandescence in a blowpipe. In a sense he was the forerunner of Welsbach.

Some Important Inventions in Industrial Chemistry.

Important advances were made in industrial chemistry. After Parker of Birmingham and Daniel Spiller had independently endeavored in 1862 to make utensils of a dried solution of nitrocellulose, but without success, J. S. Hyatt discovered in 1869 that camphor is a solvent for various kinds of nitrocellulose and thus established the great modern celluloid industry.

Dynamite was invented in 1867 by Alfred Nobel. He discovered the extraordinary absorptive powers of the infusorial earths for nitroglycerine.

Madison improved the bicycle in 1867 by providing it with radial wire spokes. This was the basis of Reynard's tangential spokes (1883) now used on all bicycles.

In 1866 O. S. Halstead of Newark, N. J., completed a submarine vessel still to be seen at the Brooklyn Navy Yard. This vessel, the "Intelligent Whale," had a trap door, which opened in the bottom of the vessel. After filling the entire vessel with compressed air to the depth of submergence the trap door was to be opened and the whole vessel converted into a diving bell. The craft was never put into commission.

Tunneling Under New York.

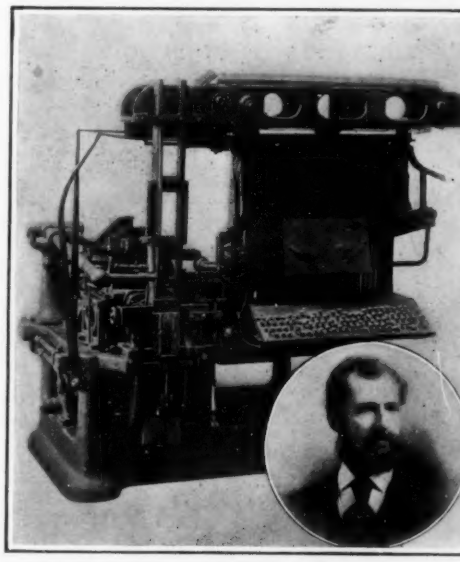
On September 5th, 1865, Alfred Ely Beach, editor of the SCIENTIFIC AMERICAN, patented a plan for conveying letters and parcels by mechanical means directly to a Central Post Office from a lamp-post letter-box. In the following year he learned of the success of experimental pneumatic tubes in Great Britain, through which small cars carrying merchandise and persons in a sitting position were successfully operated. Thereupon he invented a plan of dispatching letters pneumatically. X-shaped revolvable valves in lamp-posts were intended to catch the letters as they were dropped from above, and to hold them until the pneumatic car came along, into which they were emptied automatically. This system was patented November 13th, 1865. He built a model which was exhibited at the American Institute Fair in the autumn of 1867. A company called the Beach Pneumatic Transit Company was then organized to lay pneumatic tubes under Broadway and the East River for the transmission of mail and parcels. In order to tunnel under Broadway, the modern tunneling shield, suggested as early as 1824 by Brunel, was practically applied. The shield was pushed forward in a modern way by a series of hydraulic rams, which system Mr. Beach patented June 8th, 1869. With this shield a tunnel was driven under Broadway from Warren Street to Murray Street. A car was propelled through this tunnel by means of a blower, the blower being reversed so as to suck the car back when it had reached the end of its travel.

The Elevator is Improved.

Almost simultaneously with the steam elevator appeared the hydraulic elevator, which in its simplest form was a ram located under the carrying platform, which was moved up and down by water under pressure, working in a closed cylinder. This system of operation was first put into practical use in 1872.

After many vicissitudes the hydraulic elevator was improved, and is now in use in many modern buildings. Following this type came the geared hydraulic, in which the ram became a piston, which was attached to the moving element of a system of multiplying sheaves, over which the elevator cables were passed, thus enabling a short cylinder to effect a high lift. Hydraulic elevators were greatly developed between 1880 and 1890, during which time they almost entirely displaced the steam operated variety, and further developments were made from 1890 to 1900, when the height of buildings began to increase rapidly.

With the increased height came a demand for greater speed, but although this requirement was well met by the hydraulic, it had the objection of being uneconomical of space, and the plunger type increased greatly in cost with increased lift. The natural result of these conditions, which were steadily progressive, was to suggest electric power for operating all kinds of elevators, and the first electric elevator was installed in 1887. The first successful electric passenger elevator was built in 1889 by Otis Bros. & Co. and installed in a building on Fifth Avenue, New York. This was of the drum type, and while occupying little space this construction was ill adapted for buildings 400 to 500 feet high, on account of the enormous size of the drum necessary to wind the hoisting cables. These conditions led to the introduction in 1906 of the electrically operated traction machine, which was located directly over the elevator shaft, and includes the driving sheave. The car is suspended from one end of the cable, and a counterweight from the other. The cables pass over the driving sheave, thence around an idler and again around the driving sheave, thus forming a complete loop around these two sheaves. The driving sheave is operated through a worm gear by a moderate speed electric motor. By this arrangement the hoisting cables are given sufficient grip on the traction sheave to lift the load, while the machine is compact, economical of operation and practically solves the problem of high lifts at satisfactory speed and with perfect control. Another type of machine widely adopted is an improvement of the geared traction model by eliminating the intermediate gear, and driving the traction sheave direct by a highly efficient low-speed electric motor, and this style of machine has been almost universally adopted for skyscraper service; and in fact it is due entirely to the improvements made in elevator machinery that the skyscraper has become a possibility.



Ottmar Mergenthaler and his first commercial linotype.

1875-1885

If there is one invention that can be said to stand out more than any other in this wonderful decade, it is the invention of the electrical incandescent lamp, not only Edison's most brilliant success, but one of the greatest technical achievements in the annals of invention. Edison owed his success to clear thinking and hard work; for many another had been at work along the same lines. Edison brought his elaborate investigation of various possible filament materials to a conclusion in 1879, or at least to a point where practical results might be expected. In that year he substituted carbonized bamboo fiber for other filament materials. He was the first to recognize the fact that the filament must have a very high resistance to be efficient. His installation of one hundred and fifty incandescent lamps on the steamship "Columbia" must be regarded as the first practical illuminating plant in history. The general introduction of the incandescent lamp followed the startling exhibit Edison made in Paris in 1881.

The Edison incandescent lamp patents proved a fruitful source of litigation, but were sustained. Among the inventions unsuccessfully cited as anticipations were Sawyer's lamps (held to be included in Edison's claims) and the Jablochkoff "candle," which was invented in 1876 by the Russian engineer whose name it bears, and which was remarkable chiefly because it showed the possibility of what may be called the sub-division of light.

The problem of distributing current was certainly one of great practical difficulty and one which had to be solved before electricity could be made cheaply available. It is impossible to place the credit for the solution where it belongs. Edison certainly solved it, and so did Weston, both hitting on the idea of the three-wire system.

While Edison was busily engaged in perfecting the incandescent lamp, Charles F. Brush was experimenting with arcs. In 1878 Brush gave to the world the now famous Brush electric arc light, which was first adopted by the municipality of Cleveland. The light is still in service in essentially its original form.

In 1878 Charles F. Brush introduced his famous compound dynamos. Edward Weston's dynamos, too, were among the earliest in the market.

Gaulard and Gibbs (1880) worked out a system of distributing alternating current at high tension. They utilized induction coils, which were transformers, but which they called "secondary generators." This early transformer was one of the first steps which rendered it possible to transmit electric energy to great distances. The term transformer came into use in 1882 when Karl Déri and Karl Zipernowsky showed that by arranging the Gaulard secondary generator in parallel and by better distributing the windings and iron masses the practical requirements of every distribution system would be more fully met. Transformers revolutionized alternating-current engineering and opened up an entirely new field.

The modern transformer system, which involves transmission from a station of high potential and the reduction of the potential in the secondaries of transformers, was worked upon in a small way at the Franklin Institute in Philadelphia in 1879, and in February of that year Prof. Elihu Thomson ran two transformers by an alternating dynamo of his own construction, the fine wire primaries of the transformers being connected in parallel with the dynamo line and the secondary currents of low potential used in doing local work. Later on this pioneer work was taken up (especially after satisfactory safety devices had been produced by him) and patent 698,156, applied for on November 2nd, 1885, went through the fire of interferences from applicants here and abroad, and finally was issued with broad claims. In fact, an epitome of multiple arc distribution systems may be found in the record of interferences and other procedures in which this patent was involved. It was issued, after a long contest, in 1902.

Another electrical worker in this wonderful decade was Edward Weston, a pioneer who did much to lay the foundations of the present electrical industry. He it was who placed the art of electroplating on a really scientific footing. In 1872 he substituted dynamos for batteries in plating, and that at a time when dynamos and the distribution of electric current were still embryonic. His work in the development of the dynamo has never been fittingly recognized, especially his introduction of the laminated core in 1879. In 1874 he brought out his arc light dynamos, and from 1880 on he developed dynamos for incandescent lighting and power. Before his day it was the practice to run each arc light from a separate dynamo; he showed, probably for the first time, that arc lamps could be run in series from a single generator. As early as 1878 he devised and patented the flaming arc. He also described the cored carbon about the same time. He was the first to make arc lamp carbons in great quantities and the first to copper-plate them. From 1875 on he worked in the field of incandescent electric lighting, succeeded in producing a homogeneous carbon filament, and devised the hydrocarbon treatment process in 1875-1876. He was one of the first users of the electric arc furnace in an industrial way; for he used it in 1875-1876 to melt platinum.

Weston early realized that accurate electrical measuring instruments were a vital necessity in electrical engineering. To him belongs the credit of having devised, after infinite pains, simple electrical meters which made the measuring of volts and amperes as easy as reading the dial of a groceryman's scale.

To make light, portable, accurate instruments involved the discovery of alloys which would avoid the necessity of making correction calculations. He gave the world manganine, an alloy combining a very small temperature coefficient and a high resistance. He also gave the world several alloys with negative temperature coefficients.

In 1884, at the first American Electrical Exposition in Philadelphia, Frank J. Sprague made a sensation with his new motors. They not only gave a tremendous stimulus to central station development, as a source of supply of electrical energy, but set going a furor as to electrical traction. Sprague's stationary motors for industrial power are in use to this day. The year 1887 marks an epoch in electric traction throughout the world. Sprague's first real street railway was that for St. Joseph, Mo., but the vital point was reached when he took a contract to equip and operate a new system at Richmond, Va., with no fewer than forty cars. All was crude, but the goal had been reached,

New York in 1876. The Brooklyn Bridge is in course of construction. New York's skyline would be essentially the same to-day had the passenger elevator not been invented.

and with one great mighty leap the trolley came into its own.

The Advent of the Telephone.

Never before did electrical inventions of great value follow one another so rapidly. Indeed, it was the decade of electricity. Alexander Graham Bell invented the telephone (1876), which instrument was rapidly developed. In 1877 Emil Berliner patented the microphone transmitter, based upon the principle discovered by Du Moncel of altering the resistance of two conductors by pressure. In the same year Edison constructed his carbon telephone. To Berliner and Edison belongs the credit of having made the telephone a commercial invention.

An electric railway was built for the Berlin Industrial Exposition (1879) by Werner von Siemens. Here, for the first time, an electric current from a permanent source was led through a conductor running alongside of the track. The first public electric railway was that built in 1881 by Siemens and Halske running from the Anhalt railway station in Berlin to Lichterfelde. In 1885 the Thomson-Houston International Electric Company introduced the principle of using the rail to return the current and also the now familiar motorman's controller for regulating the speed of the car.

John Hopkinson made his classic experiments with alternating currents in 1884 at the South Foreland Lighthouse, as a result of which he laid down the conditions under which two alternators may be operated in synchronism. In the same year Elihu Thomson discussed the electro-inductive repulsion exerted by alternating current magnets on copper disks. Two years later he built his repulsion motor. In 1885 Ganz & Co. built an alternating-current dynamo (Déri-Zipernowsky's patent). This was probably the first alternating-current machine for central station use connected in parallel. All this was based on the work done by Wilde in 1868, by Marcel Déprez, and, above all, by Hopkinson.

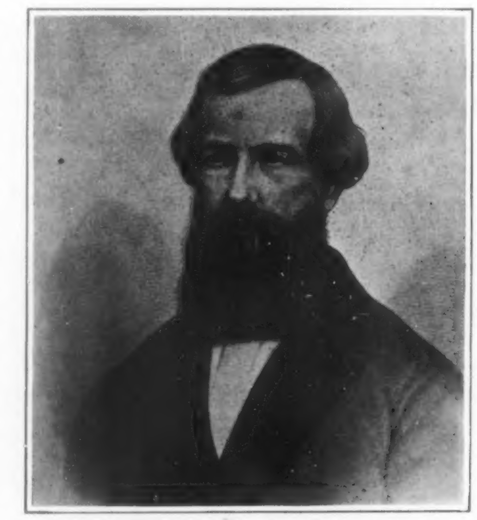
In 1885 Galileo Ferraris built a motor, consisting of a pair of electromagnets, supplied by alternating current differing by 90 degrees in phase, so that the interior rotary portion was set in motion, thus showing that it was possible to split a given alternating current into two parts, the one having a resistance free from induction, the other having self-induction. As a rotary motor armature, Ferraris employed a hollow closed copper cylinder.

Elihu Thomson's Inventions.

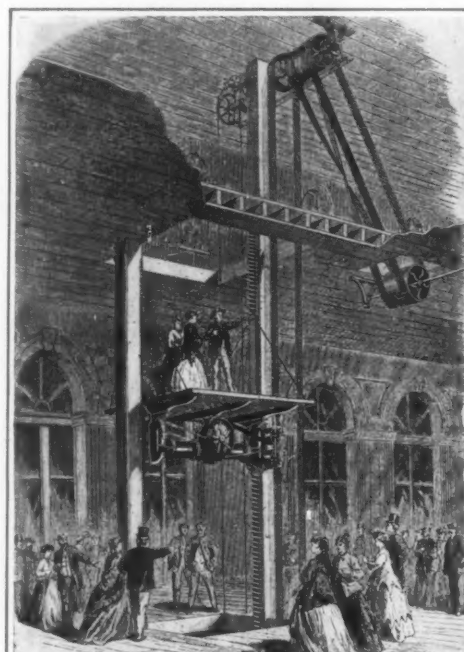
The Thomson-Houston arc lighting system began with the invention of the arc dynamo in 1879, which was patented in 1880. The specification as originally filed related not only to a direct-current machine, but also to a *three-phase alternator* with collecting rings. The machine is, in fact, the first example of a three-phase machine with or without commutation.

The Thomson-Houston constant current regulator, patented in 1881 and 1883, had a profound influence on giving the Thomson-Houston system an early start in the industry, as it maintained a definite value of current from a series line, no matter how many lights were in use. This regulator had a very extended use, and in modified form survives to-day.

Another pioneer element in the Thomson-Houston arc dynamo (1882 and 1883) was the air-blast, which overcame the difficulty of short-circuiting across the commutator slots, known as "flashing." These inventions, also, are prototypes of oil switches and switches furnished with air-blasts for extinguishing arcs.



Elisha Graves Otis, inventor of the passenger elevator.



The steam elevator of 1870. From a contemporary engraving.

The magnetic blow-out system so generally employed was first developed with the Thomson-Houston enterprise, and it has had a profound influence on all forms of control apparatus, arresters, etc. It is found in first forms in patent 283,167 of August 14th, 1883. A strong magnetic field is employed for disturbing or extinguishing the arcs formed when electric contacts are opened and when considerable voltage and considerable current are flowing. This principle is now employed on a very extended scale and is likely to be employed still more in the future. Most electrical engineers are familiar with its present relation to the art.

When incandescent lamps are run in series, one with the other, on street lighting circuits, all the sockets which suspend them are provided with film cut-outs, that is, a film of insulation is so placed in shunt to the lamp that when the lamp cuts out or is removed, the film is punctured, and thus a safety short-circuit is made around the lamp. This appears in connection with the series lamp in Thomson's patent dated September 16th, 1884. For similar purposes vacuum cutouts were invented and have attained a certain amount of use in recent times, and the prototype is 307,818 of November 11th, 1884.

Camille Faure improved Planté's accumulator in 1882 by inventing the pasted type of storage battery. Planté formed his super-oxide of lead after charging; Faure used a compound of lead oxide and lead super-oxide, which he applied directly to the negative electrode.

In 1883 Gaston Tissandier built the first electrically-driven dirigible airship. Much more important were the experiments of Rénard and Krebs of 1884. Theirs was the first really intelligently designed airship from the modern standpoint. The propeller was driven from a dynamo; the envelope was remarkable for its approximately correct aerodynamic form.

In 1883 Sir Hiram Maxim invented his automatic (self-loading) machine gun, in which he utilized the force of the recoil to reload the weapon as well as to fire it automatically. Most modern machine guns have been based upon this early weapon of Maxim's.

Edison's Remarkable Activity.

The decade was the most active in Edison's remarkable career. He perfected his motograph, his automatic telegraph systems, his duplex, quadruplex, sextuplex and multiplex telegraphs. Of these, the quadruplex system of telegraphy is of almost incalculable importance. It may be safely said that its invention rendered the high-speed printing telegraph commercially unnecessary until the present time. To the same decade belong his microtasimeter, paraffin paper, and carbon rheostat. In 1877 the phonograph appeared, one of his most original and brilliant inventions. Its first public demonstration was in the office of the SCIENTIFIC AMERICAN in the same year. Two years later he brought out his dynamo electric machines, which he designed especially to meet the need of a simple efficient means of generating current for his incandescent lamps. In 1880 he began his work on magnetic ore separation. Then followed (1880-1882) the first full-size experimental electric railway in this country for freight and passengers at Menlo Park, N. J. Not content with inventing, he started to exploit the incandescent light commercially (1881), built the first commercial lamp factory at Harrison, N. J. (1881), and organized shops for the manufacture of dynamos, underground conductors, sockets, switches, and fixtures.

How the Newspaper Printing Press Was Improved.

Andrew Campbell, famous for his printing press im-

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New York's skyline in 1914. An architectural tribute to the influence of the elevator in the development of the metropolis.

provements, in 1875 developed a press which used curved stereotype plates and printed on both sides of the web itself. Later Campbell added a folding machine. Next he built a double printing machine, each half of which contributed a perfected web to a folding machine common to both, whereby he was able to turn out an eight-page paper. Stephen D. Tucker, an inventor in the employ of Hoe and one of the most brilliant mechanics that this country ever produced, also invented a folder. He applied for a patent (1875); Campbell did not. Hence, one of the most valuable improvements in printing presses fell to the Hoes. At about the same time Tucker invented another device essential to the modern newspaper press—the collecting cylinder, by means of which the product of one circumferential half of a printing cylinder may be transposed upon the product of the following half, and thus the two brought together as a single product. Two Englishmen, Anthony and Rose, conceived the idea of splitting a web of paper into two longitudinal halves and transferring one half over and upon the other by means of deflecting bars, so that the right-hand product of a printing cylinder could be superposed upon its left-hand product and the two made up into one. This invention is now included in all double-width newspaper printing presses. Another improvement came when Ford patented a means for running the product of two printing machines into one folding machine. The rotary folder of Campbell (or Tucker), the collecting cylinder, the angle bar method and the double press arrangement—all very necessary to-day in newspaper presses—came into the possession of the Hoe Company. They were all combined into a single structure, so good that all other presses were driven out of newspaper offices. Very valuable additions were made by Crowell, an ingenious Yankee skipper who could not even read a drawing and had to work from patterns or models. With no knowledge of machine design, he invented the longitudinal folder, by which a web may be folded longitudinally while on the run and still in web form. About the same time (1879-1889) he conceived the idea of the rotary fly. This was the last device necessary to the creation of a 24,000-copies-an hour printing press, and when it was introduced (in the early eighties) the rotary newspaper printing press in all its elements became the machine it is to-day.

What the Inventor Did for the Miner and Iron Founder.

Important progress in metallurgy was made. After M. J. Holway had made experiments in bessemerizing copper (1877-1878), following the experiments of Semennikow, M. J. Brown of Sheffield succeeded in blowing Rio Tinto ores in Bessemer converters.

The modern Otto by-product coke oven, an improvement on that of Bauer and Hoffmann, was introduced in 1880. Otto's system has served as the inspiration of most later designers.

Alexander and MacCosh invented the so-called Gartsherrie process for obtaining ammonia and tar from blast furnace gases. The first proposal to utilize waste blast furnace gases for the generation of power seems to have been made by Josef von Ehrenwerth in 1883. Wilhelm Michaelis in 1876 made discoveries which showed that blast furnace slag could be added to Portland cement with advantage.

The first two-cycle gas engine appeared in 1879. It was the invention of Clerk and was distinguished by its separate compression pump, which charged the working chamber and also acted as a scavenger. The first gas engine for locomotives was built in the same year by Marcel Déprez. The gas was compressed in a suitable container, and after having been allowed to work expansively like steam, was mixed with air, exploded, and thus made to do work again.

Improving the Steam Engine: The Steam Turbine Appears.

In 1880 the French engineer, Serpollet, constructed a steam engine for tram cars, which engine was afterward used in automobiles. The engine was based upon the principle that only enough steam was admitted at each stroke to drive the piston to the end of its travel. A flash boiler was employed. It was not until the American, Stanley, came to the front with his tubular boiler that the steam automobile really came into its own. White, another American automobile designer, compromised between the principles of Stanley and Serpollet, by designing his semi-flash steam generator, which was successfully used.

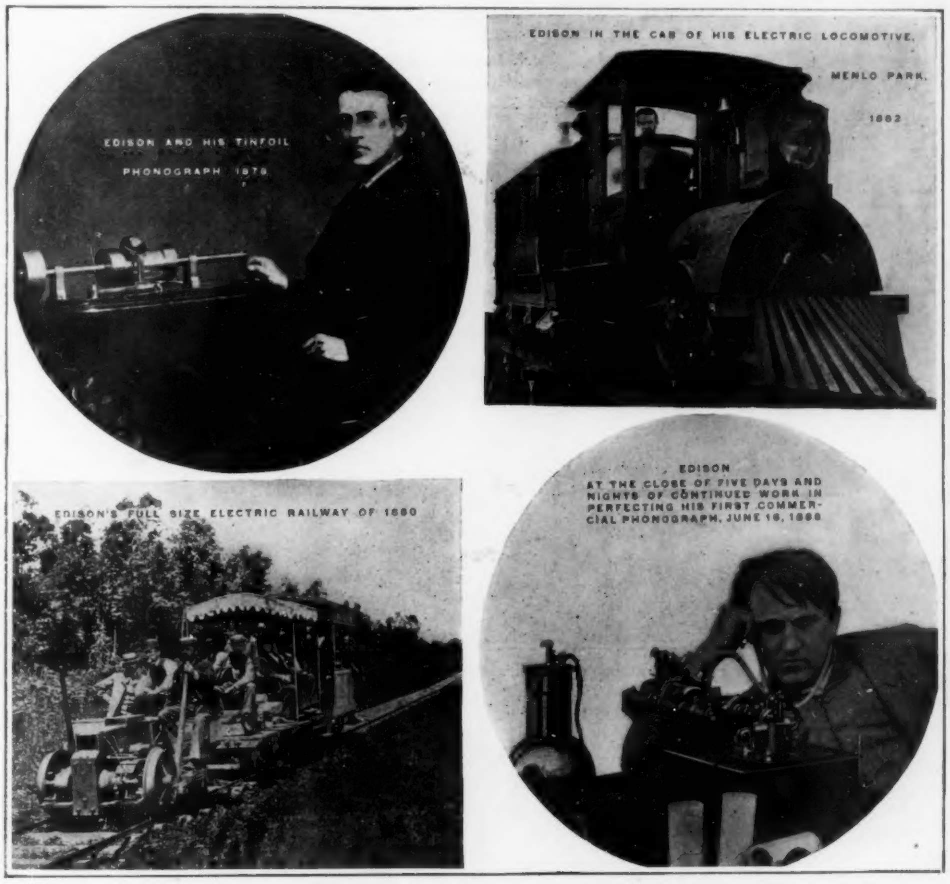
But the crowning invention in engines was the steam turbine. In 1884 Charles Algernon Parsons of Newcastle-on-the-Tyne invented his multi-cellular turbine, which utilizes steam first on the action and then on the reaction principle. His was the first steam turbine which could be directly coupled with a dynamo.

In the same year Pelton, an American, invented the Pelton wheel, in which cups are used instead of blades, the cups being so designed that they utilize the force of the impinging water to the utmost.

Mergenthaler and His Linotype.

For many decades inventors had endeavored to supply a satisfactory machine which would rapidly set type and which would enable newspaper proprietors to turn out papers more rapidly than was possible with hand composition. It was not until 1888 that such a machine was invented. It was the invention of Ottmar Mergenthaler, and it worked on an entirely new principle. Instead of seeking to set the types and after their use to distribute them among their respective receptacles in order that they might be automatically composed—the principle on which previous inventors had worked—Mergenthaler composed the type-matrices, and from these cast, as a single piece, a line of characters. Hence, his machine was called a "linotype." Mergenthaler's matrix was of brass, flat and rectangular, having a V-shaped notch cut deep into its upper end, the edges of the notch being lined with small hook-like projections. These projections were arranged to act like the convolutions of a flat lock-key; because of them a matrix could drop from the V-shaped ward bar, from which it hung during its automatic distribution after use, only into its own reservoir or channel of the matrix magazine. The convolutions of all the matrices of each character were alike, but those of no two characters were the same. The matrices were allowed to drop into their proper places in a line in response to the working of a keyboard. They were automatically justified, transported to the casting mechanism and pressed against the mouth of a slot or mold filled at the proper moment with molten type metal. After that the matrices were returned to their respective magazines.

On the heels of the linotype came another device—the "monotype," invented by Lanston, which has found its field more in the book and periodical printing office. The monotype consisted of two independent mechanisms, the one a keyboard by means of which the operator was enabled rapidly to perforate a paper ribbon with holes which represent characters, and the other a type-casting mechanism to which perforated tape thereafter was fed. The latter device comprised a movable frame in which the matrices of 225 characters were fastened, a type mold, automatically adjustable to suit the various widths of the characters of the alphabet, with which a metal pump was connected, and pneumatic mechanisms for controlling the position of the matrix-carrying frame, and the width of the type mold. To these was added a general mechanical organization which enabled the perforations of the ribbon, by means of air, as it was drawn through the machine, to place the matrix frame properly and set the mold for each character needed, while the pump and co-operating parts acted to cast the character and place it in its correct position in a tray, or "galley," at the rate of 150 characters a minute.



Some of Edison's work in the decade 1875-1885.

The Invention of the Automobile.

The first really successful modern volatile hydrocarbon automobile appeared in 1883. It was designed and built by Gottlieb Daimler. His success seems to have been due very largely to his automatic hot tube igniter, which was soon used for both stationary and portable internal combustion motors. George B. Selden of Rochester, N. Y., applied for a patent on a volatile hydrocarbon automobile in 1876, but never built a car until he became involved in patent litigation many years later; but to Daimler must be conceded the credit of having given us the modern automobile as we know it. Much credit is also due to Karl Benz of Mannheim, who in 1885 built the first four-cycle volatile hydrocarbon motor with electric ignition, which motor he mounted on a tricycle. Although he designed this in 1885, he did not exhibit it until 1888, and then at the Industrial Exposition of Munich.

Improving the Submarine Boat.

In 1876 J. P. Holland built a submarine vessel (the "Fenian Ram"), following the Fulton system of control by vertical and horizontal rudders. She was fitted with an air gun which could be discharged under water, and was probably the first submarine torpedo boat, if we give the word torpedo its largest significance. Holland was preceded by a year, however; for in 1875 Garrett of England brought out a vessel which was propelled by a steam engine, steam being given off at gradually reducing pressures. Later Garrett became associated with Nordenfeldt, who added new ideas, among them down-haul screws carried amidships either side of the vessel to haul her under water. By varying the speed of the side propellers the depth of submergence could be controlled. Nordenfeldt built submarines for Turkey, Greece, and Russia. In these internal torpedo firing tubes were fitted for the first time.

In 1880 Alexander E. Brown installed the first mechanical ore unloader to take ore from the hold of a boat and deliver it either to cars or to stock piles without rehandling, an invention that marked the first step in the remarkable American system of ore handling. No radical improvement in the principle of ore unloading was made for nearly twenty years.

Paper Pulp and Its Preparation.

During this process the Ekman paper-pulp process was markedly developed. Mechanical difficulties surrounded the operation from the start, though the quality of pulp produced was excellent. The digesters in which the wood was cooked were lined with lead and the heat developed in the acid liquor proved to be exceedingly disturbing, as while the lead expanded during the application of heat, it did not contract again when cold. The cost of repairs to digesters necessitated by the behavior of the lead lining was heavy, amounting

to $10 a ton on the total production. The difficulty was overcome by the invention of a digester lining composed of heavy cement backing, faced with brick, the latter being pointed with litharge and glycerin. The invention of a digester lining was one of the important early contributions of the chemical engineer to the development of the industry.

The magnesium bisulphite process originated by Ekman in Sweden, and developed by Charles S. Wheelwright and his brothers in this country at the Richmond mill in Providence, R. I., has been modified in several important particulars, the chemical solvent now employed being bisulphite of lime. Many different kinds of pulp are obtained, according to the system of cooking employed.

The sulphite process of cooking wood is not applicable to all woods. It works best with spruce and coniferous woods generally, and the several qualities of sulphite pulp depend on the system of cooking employed. The Mitscherlich process, which bears the name of the inventor, yields a product by long cooking in a weak solution of sulphurous acid under low pressure, which is remarkable for strength of fiber. The wood is steamed for a few hours before being boiled with the acid liquor. The Rittner-Kellner quick-cook process is an improvement on the other processes, and is the one generally used in this country.

Perhaps the most important invention in pulp-making processes, especially in view of recent work in the utilization of waste wood, dates from 1883, when Dahl introduced the sulphate process for the treatment of straw, a modification of which is now applied to the production of pulp from coniferous woods that are not amenable to other treatment. The operation of boiling in this process is carried out with a solution of caustic soda containing small amounts of sulphate and sulphide of soda. The sulphate of soda does not affect the wood and is used as a source of alkali and sodium sulphide. The principle of the process depends on the fact that in soda recovery, when the concentrated liquors are burned to ash, the sodium sulphate is reduced to sulphide by the carbonaceous matter derived from the wood, while the soda, in conjunction with the organic matter, is converted into sodium carbonate. The liquors are causticized in the usual manner, the lime converting the carbonate into caustic soda, and having little action on the sodium sulphide.

1885-1895

Although the decade was not so fruitful in pioneer electrical inventions as that of 1875-1885, it did bring out much that was new and startling. S. Z. de Ferranti built the first alternating current central station of London, remarkable for its completeness of equipment. It served as a model for later installations. The year 1887 is memorable for Tesla's invention of the polyphase alternating current motor, which made it possible to transmit electrical energy economically. On another page in this issue Mr. Tesla has told how this and other inventions of his sprang into being. The first alternating current machine for generating polyphase current seems to have been built in 1888 by Hasselwander of Offenburg. In the same year Charles S. Bradley patented a two-phase motor. The first installation for transmitting multi-phase alternating current at high tension was built in 1891 by Michael O. von Dolivo-Dobrowolski of Berlin between Lauffen and Frankfurt.

Hertz Lays the Foundation of Wireless.

The year 1887 is memorable for the publication of Heinrich Hertz's classic studies, which experimentally proved that invisible electromagnetic waves can be sent through the ether with the speed of light waves. To prove the existence of the waves Hertz employed secondary conductors of condenser-like form (Hertz resonators). Hertz's work marks the beginning of modern wireless telegraphy.

In 1890 Edouard Branly invented the coherer, the first detector of the electric waves employed in wireless telegraphy. The instrument was independently invented by Lodge. Although it has outlived its usefulness, without it the art of wireless telegraphy might not have developed so rapidly. The tapper, which decohered the iron particles in the tube and thus rendered it responsive again, was invented by Popoff in 1895, without any thought apparently of its subsequent utility in wireless communication.

The telautograph, an instrument for transmitting drawings and writing electrically, was invented in 1890 by Elisha Gray. His instrument had as its essential feature a transmitting stylus or pen, the movements of which were analyzed into two components perpendicular to each other. These components varied the resistance of an electric circuit and caused the receiving stylus to retrace the movements of the transmitting stylus. Improvements were made in 1894 by Cerobottani, Dennison, Gruhn, and Grzanna.

Electric Welding and Other Inventions of Thomson.

The Thomson electric welding patents were applied for in 1886, and were issued on August 10th of that same year. They were the result of considerable work done before the filing in establishing the art of electric welding. Along with the development of the art of electric welding under the Thomson process there was also electric forging and brazing as instances of the use of electric welding transformers, the peculiarity of which is that the secondary of the transformer consists of only a single turn. The principal patents are 396,009 and 396,010, issued to Thomson January 8th, 1889.

The fundamentals of the Thomson repulsion motor and repulsion apparatus generally were patented May 17th, 1887, the experimental work being done about May, 1885, and onward.

In like manner, attention may be called to Thomson's inventions relating to alternating current magnetic systems, including the "shaded pole" and "shifting magnetism" (1889 and 1890), pioneer inventions in this field.

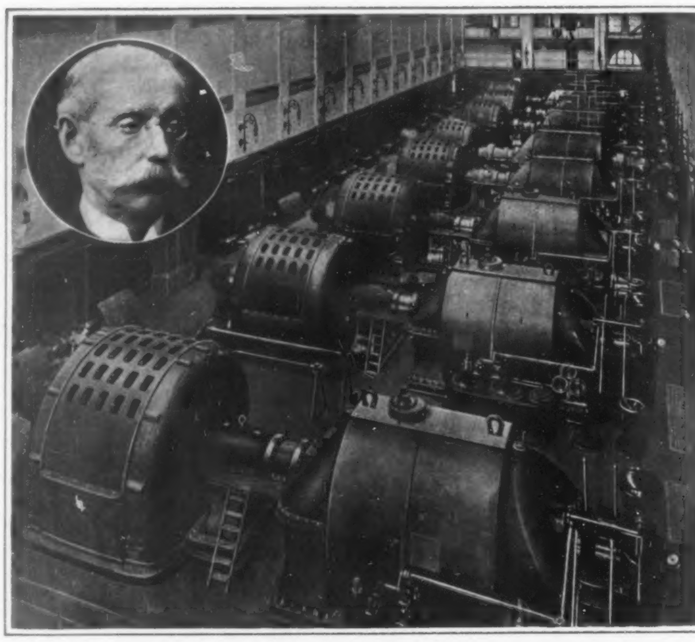
The well known engineering device, known as the "constant current transformer," is seen in its earlier forms in Thomson's patents, 400,515 and 400,516, of April 2nd, 1889.

As bearing on the constant current transformer systems now in such extended use, especially in arc lighting in cities, reference may be made to the pioneer patent, 516,846, granted to Thomson March 20th, 1894. These constant current transformers were based on the principle of repulsion discovered by Thomson years earlier, and they practically supplanted arc light dynamos. They are now greatly used to supply energy to mercury arc rectifiers where direct current is employed to operate a series of magnetite arc lamps. They furnish constant current to alternating current arc lamps, and are likely to be used in the future with the series high power incandescent lamps of the nitrogen filled type.

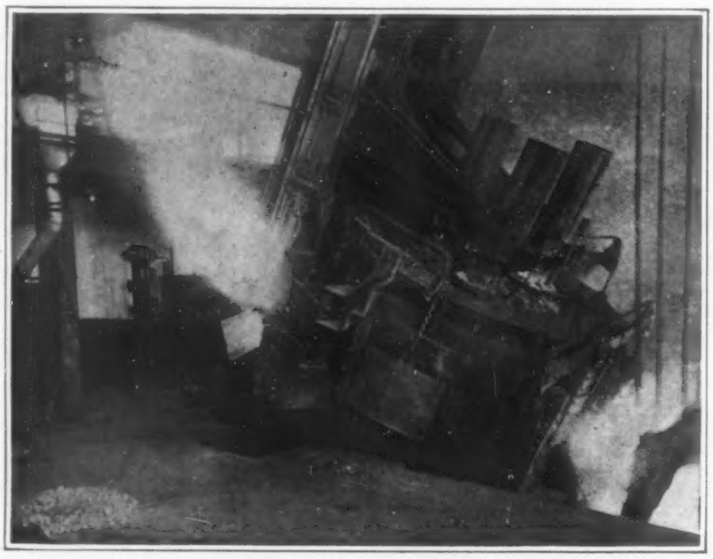
As an important invention which lay fallow for some time may be mentioned Thomson's "electric air drill," the subject of patent 534,730, of February 26th, 1895. The patent is fundamental, and practically covers the form in which electrical energy is now employed for the working of rock drills. In fact, the so-called "electric air drill" is made under this patent.

The oil immersed transformer, as it is commonly employed in the arts to-day, appears in Thomson's patent 428,648 of May 27th, 1890.

It may be interesting to note that the first endeavor to produce high frequency currents by high frequency dynamos was made about 1890, and a machine produced which gave about 4,000 to 5,000 cycles, and which was capable of being driven at still higher frequencies if necessary. This machine was used in the classic experiments on the effects of high frequencies on animal bodies by Dr. Tatum about 1891 or 1892. The machine itself was an original type of inductor dynamo, so called,



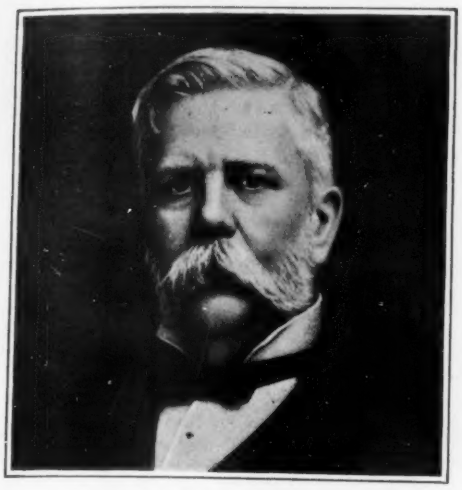
A typical central station in which Parsons turbines are used to drive electric generators. The portrait is that of the Hon. C. A. Parsons.



The electric furnace is radically transforming the steel industry.

The electric welder of Elihu Thomson.

The machine here shown will weld two hundred steel bands in an hour. It takes only a few seconds to make an electric weld. A heavy current of electricity at a low voltage is passed through the abutting ends of the metal pieces to be welded, thereby generating heat locally at the points of contact, while at the same time prssure is applied to force the parts together.



George Westinghouse, whose invention of the air-brake made modern high-speed railway travel possible.

the original machine itself being still used in electric testing. It is described in patent 432,655 of July 22nd, 1890.

An important invention bearing on interpole work, now such a decided factor in the construction of dynamos and motors for continuous currents is shown in patent 459,422, filed in 1885 and issued September 15th, 1891. This dynamo appears to be a pioneer invention in that the separation of the series and shunt coils on the field for securing better commutation and at the same time compounding a machine, are found. The principle has been applied in improved forms since then, and, of course, has given superior results.

Some Work With the Electric Furnace.

The possibilities of the electrical furnace were never before so brilliantly revealed as in this decade. In 1862 Woehler discovered that water acting on calcium carbide would produce acetylene. The next step was to make calcium carbide cheaply. An early attempt with the electric furnace was that of Henri Moissan (1892), who succeeded in making calcium carbide out of marble and sugar carbon. Then came Thomas L. Willson, to whom the credit is really due of placing the manufacture of calcium carbide upon an industrial basis, which he achieved in 1892 in co-operation with Dickerson.

Paul Héroult constructed the cathode furnace (1887) for uninterrupted operation and thus becomes the founder of the electrometallurgy of aluminium according to the smelting method.

Edward G. Acheson succeeded in 1892 in making silicium carbide in the electric furnace—an abrasive which has been known to the trade as carborundum. He also obtained artificial graphite in the electric furnace.

Power Generation—The Diesel Engine.

The year 1893 marks the publication of Rudolf Diesel's "Theory and Construction of a Rational Heat Motor," in which he set forth the principles of the well-known Diesel engine. Diesel engines were first exhibited in 1896 at the Münchner-Austellung für Kleinkraftmaschinen.

In 1887 Gustaf de Laval invented his high-speed steam turbine, in which the potential energy of the high-pressure steam is transformed into kinetic energy in a single stage and imparted to the shaft. In the same year he designed his centrifugal cream separator, which ever since has been widely used in dairies. He seems to have been preceded by Elihu Thomson, who patented the continuous separation of cream from milk by centrifugal force, the first example of a continuously operating centrifugal machine with ducts for the introduction of the new charge, and separate ducts for the exit of the separated constituents. During the life of this patent the centrifugal creamers which were sold in the United States were put out under it, coupled with another of De Laval, but the broad patent was one to which reference has been made, viz., that numbered 239,659.

In 1894 Bénier patented the suction producer-gas plant in which the motor is made to draw its gas from the generator, thus producing a depression in the generator which is filled by air below atmospheric pressure. This air is mixed with steam and forms new gas in passing over the layer of glowing fuel.

The first attempt to use compressed illuminating gas was made by Julius Pintsch in 1891. His system, properly developed, made it possible to illuminate railway trains with gas.

The Cyanide Process—Artificial Silk.

The famous McArthur-Forrest cyanide process, which has been of immense importance in gold mining, was brought out in 1887 by Robert William Forrest, William Forrest, and John McArthur. These investigators found that the effect of potassium cyanide depends upon the weakness of the solution. The gold mines of the Transvaal took up the process almost as soon as it was introduced.

The first commercially successful process for making artificial silk was that brought out in 1885 by Chardonnet, who squirted nitro-cellulose under pressure through small holes in water, alcohol, chloroform or the like, the threads congealing at once.

John B. Dunlop, a dentist of Dublin, Ireland, invented the pneumatic tire in 1890, as we know it to-day. He seems to have been quite unaware of Thomson's pioneer work in the same line (1846).

Artificial Flight—Some Early Experimenters.

Experiments were made in this decade, which cleared away some of the difficulties that confronted inventors interested in aerial navigation. In 1890 Otto Lilienthal of Berlin began his gliding experiments with a motorless aeroplane of his own design. Simultaneously Langley and Maxim began their experiments. Lilienthal was killed in a machine of his own construction in 1891. Langley in 1896 succeeded in making the first small motor-driven aeroplane which ever flew. He continued his experiments until 1903, when a full-sized machine of his failed to mount into the air because of a defect in the launching apparatus. The machine was successfully flown for a short distance in 1914 by Curtiss. Hiram Maxim's machine was built in 1894. It was of enormous proportions and had a motor steam engine of 360 horse-power. While it might have flown for a short distance, it came to grief because it tore away the guard rails which were intended to hold it on its track.

Improving the Phonograph.

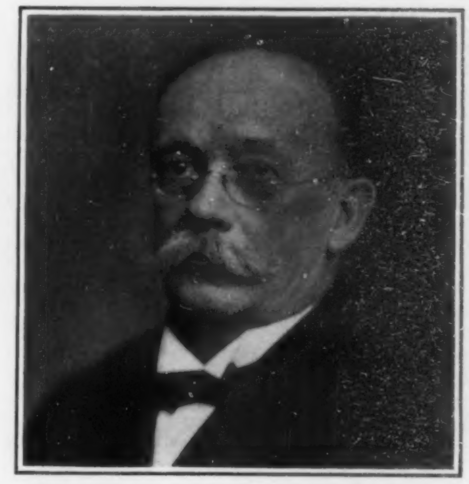
Edison's experimental success with his tinfoil phonograph of 1877 proved the starting point of much valuable investigation in sound production by himself and others. In 1886, Dr. Chichester Bell and Charles Sumner Tainter patented their method of recording and reproducing sounds by engraving a wax or wax-like substance, thus producing records that could be removed from the machine, handled and transported. In 1887, Emile Berliner invented the gramophone or disk graphophone and worked out for practical use the system of duplicating disk records, which has been in use ever since.

A Record of Achievement in Submarine Invention.

Goubet of France built several submarine torpedo boats between 1885 and 1890. The novel feature was his propeller, which worked on a universal joint so that it could be changed as to the direction of thrust. It took the place of vertical and horizontal rudders. Prof. Josiah Tuck carried on experiments with his submarine ("Peacemaker") in the Hudson River in 1885, using caustic soda which was introduced into a boiler to generate steam. His boat had a water lock through which a man, clad in a diving suit, could pass. This was the principle that Jules Verne embodied in his imaginary "Nautilus," fondly imagining that the idea was his originally. Several other submarines were built in Europe during this period. The most successful of these was perhaps the "Gymnote" built in France after the designs of Dupuy de Lome and Gustave Zédé.

In 1893 the United States Navy advertised for bids for the construction of a submarine. J. P. Holland, George C. Baker, and Simon Lake handed in plans. Baker's design was based on the performance of a vessel he had experimented with in 1892. Holland submitted plans for a steam vessel of the diving type with horizontal rudders at the stern for changing the inclination of the vessel, as first used by Fulton. Lake submitted a design for a vessel with an inner and outer hull, the inner space to be utilized for water ballast.

The first successful Maxim machine gun. Beside the gun are Sir Hiram Maxim and the Prince of Wales, later King Edward.



Edward Weston, pioneer inventor of dynamos, arcs, and electrical measuring instruments.

This vessel was designed to be operated submerged on a level keel by the use of hydroplanes; bottom wheels were provided to enable the vessel to be navigated on the water bed itself; air locks were called for to enable the crew to escape in case of danger. Holland secured the Government award because of his previous experience. His vessel, the "Plunger," was not a success, due to her enormous steam installation, which made the interior of the boat unbearably hot, and to her lack of stability. Lake's idea of running along the bottom on wheels—an entirely new conception in the art—received its first demonstration in 1894. This craft was the germ from which later emerged his "Argonaut" (1896-1897), the first submarine to be fitted with an internal combustion engine.

1895-1905

This is the decade of the aeroplane and the airship and of wireless telegraphy.

After two years of preliminary study, research and experimenting Count Ferdinand von Zeppelin completed his first great rigid-frame dirigible airship, the pioneer craft of this type. About the same time Santos-Dumont was making sensational flights with airships that could hardly be considered an improvement over those of Tissandier and Renard and Krebs, except that they were driven by modern light gasoline engines which could easily be applied to the dirigible without the exertion of any great inventive ability. Much more important was the work of the Lebaudys, who really created the semi-rigid type. The non-rigid system was developed by von Parseval. The collapsible Parsevals were quickly adopted by the German army and were later improved by Astra-Torres in France.

The Wright Brothers Invent the Flying Machine.

But the decade is much more memorable for the actual realization of a flying machine. Octave Chanute continued Lilienthal's gliding experiments with biplanes and multiplanes, his experiments proving that the trussed biplane with some device was necessary to shift the center of air pressure in order to maintain equilibrium. He was the mentor of the Wright Brothers, who began their investigations with similar gliding experiments which culminated in the modern biplane flying machine—a machine driven by a gasoline motor, provided with wing warping devices. For the first time in history, a man having a motor-driven machine flew in 1903 for a distance of 260 meters. In the same decade belong the experiments of Ader; but there is no evidence that his "avion" did more than to rise from the ground and fall back again.

Marconi and Wireless.

In 1895 Guglielmo Marconi invented the first practical wireless telegraph apparatus. It contained very little of his own, but in this respect it did not differ from many pioneer inventions. Yet, it was invention in the true sense of the word because a new result was produced with well-known apparatus ingeniously combined. In 1901 Marconi for the first time signaled across the Atlantic Ocean. The development of wireless is traced in the article on Communication in this issue.

The work done with the electrical furnace resulted in the establishment of the aluminium industry. Charles M. Hall discovered in 1886 that natural cryolith is a proper flux and solvent for clay, and with a current derived from seven Grove elements and with carbon electrodes he succeeded in producing the first pieces of aluminium. In 1889 Héroult produced aluminium bronze electrolytically by melting alumina and decomposing the molten mass with the electric current.

F. A. Kjellin, Ernesto Stassano, and Paul Héroult simultaneously and independently discovered about 1900 that if iron is to be reduced from its ores electrically, the iron must not be left too long in the electric arc, as

otherwise it will absorb too much carbon and suffer in quality. F. A. Kjellin, accordingly constructed an electric furnace in which this idea was embodied, and on March 18, 1900, obtained the first good quality of electro-steel, free from blowholes. Paul Héroult in the same year built a furnace in LaPraz, in which he also produced very pure iron and steel by smelting the ore in a crucible of refractive material in which the carbon electrode did not actually touch the iron.

In 1897 Hans Goldschmidt of Essen invented the well-known thermit process. Thermit, however, was not introduced commercially until 1899. The modern process of autogenous welding was introduced in 1905 by Fouché, oxygen and acetylene being used in a specially constructed blowpipe.

An attempt to reduce nitrogen from the air electrically was made in Niagara Falls by Bradley and Lovejoy in 1900. This experiment, while not commercially successful, at least served to inspire later work. Thus Christian A. Birkeland and Samuel Eyde built their Norwegian plant in 1903, using electric arcs spread out by magnets so as to obtain a great heating surface.

The Development in Electrical Engineering.

There were many other achievements in electrical engineering that deserve mention, but only a few can here be listed. In 1898 appeared the telegraphone or telephonograph, the invention of Poulsen and Pedersen, two Danish electrical engineers. The instrument is a beautiful combination of the telephone and phonograph, sound being magnetically recorded upon steel disks or wires and reproduced by means of telephone apparatus.

In 1898 Hermann Theodor Simon of Goettingen studied the superposition of alternating upon direct currents, and invented the singing arc lamp, which may be regarded as a kind of radio-phonic instrument.

The so-called "musical arc" has been variously called the Duddell and the Poulsen singing arc. This was a discovery made by Prof. Elihu Thomson years before the others had entered the field, and it forms the subject of a patent No. 500,630, filed July 18th, 1892, and issued July 4th, 1893. It covered broadly the shunting of an electric discharge apparatus such as an arc by inductance and capacity for producing automatically high frequency waves of a continuous nature. It was, in fact, the first apparatus of the kind which would give that result, the Duddell musical arc being practically the same thing, and the Poulsen arc being a slight modification.

In 1901, Frank J. Sprague, the well-known American electrical engineer, invented his famous multiple unit system of control for electric railways. In this system all cars are provided with two motors, and so connected by Sprague's coupling devices that all the motors of the train are switched in and out by a single motorman at the head of the train. The system was put into service on the south side elevated railway of Chicago under forfeiture contract. The multiple unit system is the sole dependence of the roads in New York and Boston. Sprague's fundamental and basic patent on this system contains nearly three hundred claims.

In 1902 J. F. Stone's system of electric train lighting was introduced in the United States. In this system the current is delivered by an auxiliary battery to which the car rod lamps are connected. A regulating apparatus of special design renders it possible to supply uniform current, whatever the speed of the train may be. Stone's system was improved in 1903 by Aichele by the use of a new regulating system which eliminates the need of any attention whatever on the part of the train crew.

B. G. Lamme of the Westinghouse Manufacturing Company brought out the high tension motor for single phase alternating current in 1902. The motor was soon introduced on electric railways.

The Swedish engineer, Jungner, invented the alkaline nickel-iron storage battery, but it remained for Edison (1903) to bring the battery to commercial perfection. Edison made his cell of sheet metal instead of hard rubber and filled the plates with hydraulically pressed briquettes, composed of iron and graphite for the positive plate and nickel and graphite for the negative plate. He provided outlets for the escape of gases as well as inlets for electrolyte.

Edison worked hard during this decade on the motion picture camera and projector and did much to give us the modern motion picture industry. He brought his magnetic iron ore concentrator to a high state of efficiency. Unable to utilize the plant commercially because of the Mesaba ores which then began to be worked on a cheap scale, he applied part of his apparatus in developing his Portland cement process.

Thermodynamic Developments.

The steam turbine was markedly developed during this period. C. G. Curtis invented in 1896 his multi-stage pressure turbine. A. Rateau in 1898 constructed his multi-stage pressure turbine. Zoelly in 1902 constructed a multi-stage pressure turbine which is essentially similar in principle to that of Rateau. A. Rateau invented the first turbo-compressor in 1900 and a turbo-pump in 1902.

The principle of utilizing internal work in liquifying air as well as the counter-current principle of refrigeration was discovered in 1898 by Karl P. G. Linde. The outgoing air was used to cool off the air still contained within the apparatus so as to produce a cumulative refrigerative effect. He built a refrigerating machine on this principle with which very low temperatures were reached.

In 1898 Ochelhäuser of Dessau installed an engine in the Hörde Iron Works for the conversion of blast furnaces into mechanical energy; the engine itself was patented in 1896, and was a two-cycle double piston engine. The Körting blast furnace gas engine was brought out in 1898. Cockerill of Seraing, Belgium, introduced a four-cycle blast furnace gas engine in 1899. From this the two-cylinder blast furnace gas engine of the Nürnberger Maschninenbau-Aktiengesellschaft was evolved.

In 1904 James A. Gailey brought out his dry blast process for the production of iron and steel. He solved the problem of drying the air by freezing out the water. Although he encountered great difficulties in introducing his process it is now recognized as one of the most important contributions to the steel and iron makers art, effecting as it does remarkable economies.

The American iron industry suffered a great change in this decade. The Mesaba ores were being introduced. Since the blast furnaces were far removed from the Lake Superior beds cheap handling was an essential, a consideration met by Brown's bridge cranes, cableways, and trolleys. A radical departure was made in ore handling when G. H. Hulett in 1898 invented the automatic ore unloader bearing his name. It did away with the shovelful as the unit of bulk and substituted the grab bucket of ten tons capacity. The entire machine was made to travel along the dock to reach all hatches without shifting the boat. This machine reduced the cost of handling ore from nineteen cents a ton to less than six cents a ton. While this machine was being developed F. E. Hulett designed and patented an excavating bucket that could be controlled entirely by ropes.

Industrial Chemistry.

In 1897 Karl Engler made exhaustive researches on the decomposition of hydrocarbons when subjected to heat and pressure. Thanks to him much light was shed upon chemical reactions, which take place when oil is cracked. Most cracking processes are based upon the methods disclosed in patents taken out in 1890 by Dewar and Redwood. The Dewar and Redwood process is in turn an outgrowth of the Krey high-pressure distillation process of 1887.

The method of hydrogenating soft fats and oils, whereby it is possible to convert vegetable oils into substitutes of lard and some fats into hard fats of greater commercial value was discovered in 1902 by P. Sabatier and J. B. Senderens.

The separation of ores by oils was introduced in 1902 by W. Elmore. The ground ore mixed with the residue of petroleum distillation was placed in rotating cylinders so that oil and pyrites are intimately mixed. The oil is then centrifugally separated.

In 1899 William Draper constructed a loom with automatic shuttle-changing mechanism, the first practical success of its type, and the result of ten years' experi-

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The Wright flyer of 1905-1908.

Samuel Pierpont Langley.

One of Langley's successful models.

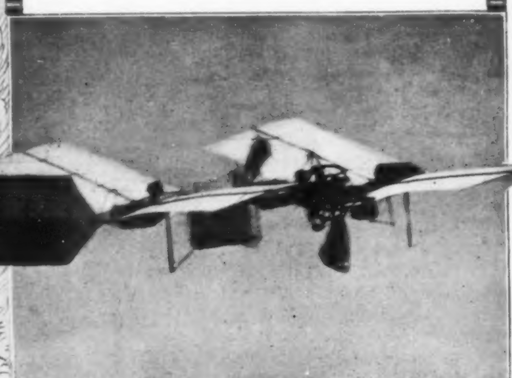


Photo by Hollinger

Orville Wright.

Otto Lilienthal and his glider.

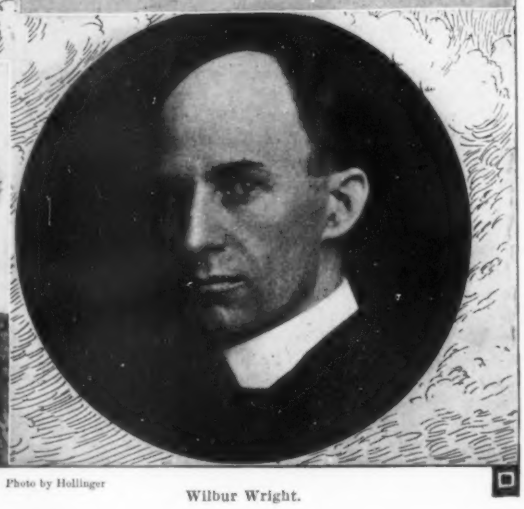


Photo by Hollinger

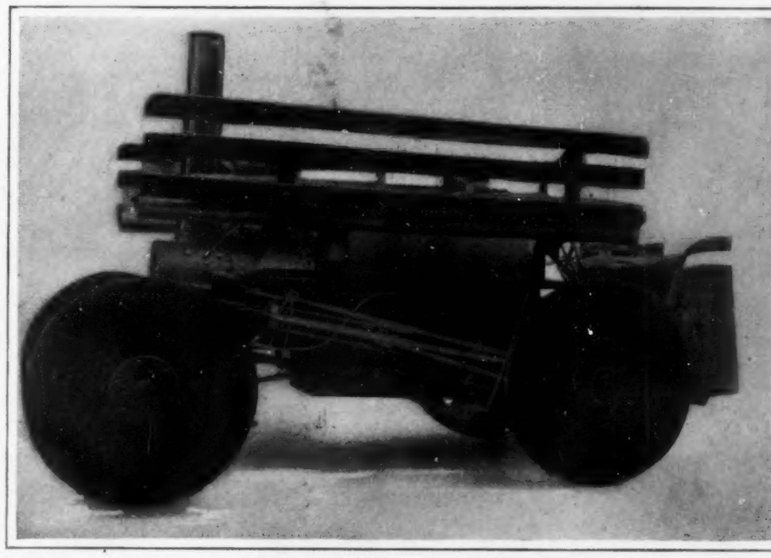
Wilbur Wright.

Pioneers in artificial flight.

The Rise of the Automobile

From the Snorting Road Locomotive to the Swift Noiseless Car of To-day

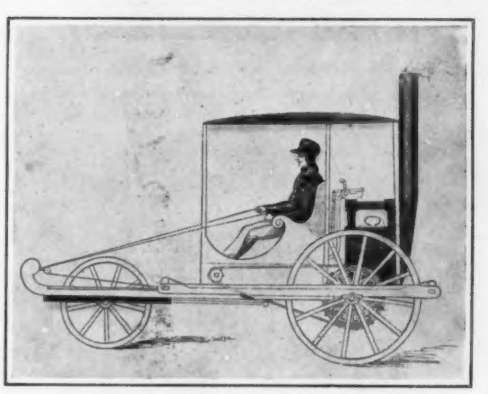
IT would hardly seem necessary to turn back seventy years to trace the history of the automobile. Surely any full-grown man can recall his first view of a chugging horseless carriage. And yet, in 1845, when the SCIENTIFIC AMERICAN was established, the power-driven road vehicle was an old story. Joseph Cugnot of France and his three-wheeled steam carriage that actually ran for a short distance and then upset because it was too top-heavy to take a sharp turn at three miles an hour, was even at that early day a historic event seventy-five years old. It was in 1802 that Richard Trevithick, in England, was ruled off the highways for joy-riding when he ran into a fence at the frightful speed of 10 miles per hour and ripped off several palings.



Richard Dudgeon's steam road car, built in 1860.
The original machine, of which this is a duplicate, was constructed in 1855.

Of course, the automobile was an old story, for it was the father of the locomotive. The idea of running locomotives on rails was an afterthought. The first of them were run on the common highways, and we owe to these early machines the development of many of the essentials of the modern motor vehicle. The use of stub steering axles in place of the fifth wheel dates back to 1819. A transmission gear with two speeds appeared on a steam carriage in 1821 and the same car was fitted with a condenser similar to the early type of radiators on gasoline automobiles. In 1825 a 10 horse-power engine was developed, using a *flash boiler*. A power-driven fan—not for cooling the engine, of course, but for furnishing the furnace with forced draught—appeared in the early thirties, and at about this time the clutch was developed. The differential was used in 1840, although it had been known as a mechanical movement for many years prior to that time, and finally, in 1845, came the invention of the pneumatic tire. This was a canvas rubber inner tube incased in a leather shoe or outer tube.

Thus we see that when the SCIENTIFIC AMERICAN came into being the automobile, as a pleasure vehicle, had had a very thorough trying out, but it had been found wanting, and, by the public at large, had been relegated to a place in the vast museum of impractical inventions. Indeed, England had already begun its oppression of the motor vehicle by burdening it with excessive tolls and restrictions, that grew increasingly irksome, until, eventually, it was practically barred from the highways by an act forbidding a speed of more than four miles per hour and requiring that each power-driven vehicle be preceded by a man waving a red flag. Not until 1896 was this foolish law repealed, and it was responsible for the paucity of British contributions to the development of the automobile in the earlier days of its present era. However, in marked contrast to the spirit of the times, the SCIENTIFIC AMERICAN took a keen interest in power-driven vehicles and tried to encourage and promote them. We find even in one of its earliest numbers—that of October 2nd, 1845—a front page illustration and description of a steam carriage for common roads which was steered with a pair of reins. Undoubtedly the most important contribution to the motor vehicle during the early history of the SCIENTIFIC AMERICAN was that of Richard Dudgeon. In 1855 he and two other engineers were discussing the feasibility of driving a road vehicle with power, and made a compact that each one of them would undertake the task. The other two inventors failed to produce anything of value, but Richard Dudgeon's machine was a success. It made frequent trips about the country at high speed. Forty miles an hour is the record it hung up, and frequently it made speeds of 35 miles per hour. Unfortunately, it was destroyed while on exhibition, in the Crystal Palace fire of 1858. A second machine was built by Dudgeon in 1860. Both of these machines were virtually locomotives adapted for road travel. A power vehicle of much more modern appearance was developed by the House brothers in 1866, and it attained a speed of 30 miles per hour. About this time the steam fire engine made its appearance, and steam began to be used more and more for traction purposes.



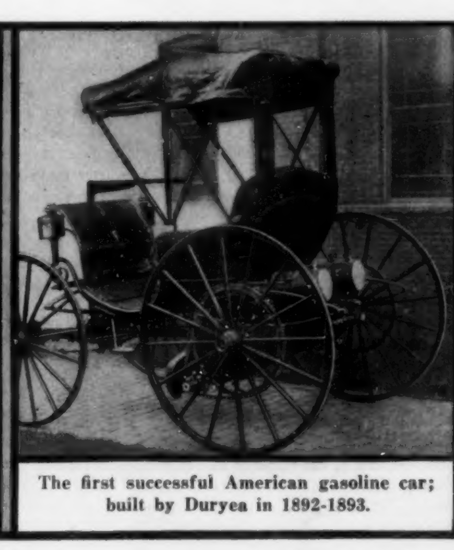
A steam vehicle steered with reins.
From the SCIENTIFIC AMERICAN of October 2nd, 1845.

In England, during the same period, the steam vehicle was used for commercial transportation purposes. Steam stages came to be quite common. In 1861 the famous "fly-by-night" was produced and it used to thunder through the villages after dark at speeds of 10 and 15 miles per hour. So frequently was the owner of the car arrested for disturbing the neighborhood that eventually he and his crew had to put on firemen's helmets and coats and equip their machines with fire hose and buckets so that they could fool the constables into thinking that they had a legitimate reason for driving out at all hours of the night.

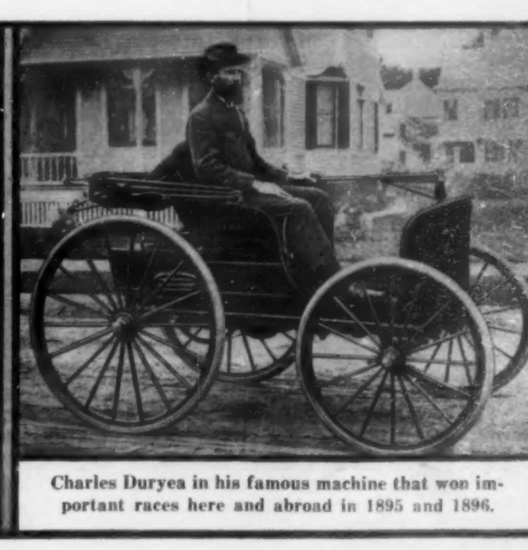
All this time the automobile was merely waiting for the proper type of engine to make it a popular success. One of the earliest uses of steam produced with gasoline fuel was that of R. E. Olds, who in 1887 built a buggy that was driven by a steam engine. However, the steam boiler was of the tubular type. It was in 1889 that Serpollet, in France, revived the flash boiler principle and gave the steam carriage a fresh impetus that has lasted to the present day. At first even he used coal fuel, but later he changed this to kerosene, and eventually gasoline was the accepted fuel. So successful did this type of boiler prove that it made steam a very close competitor of gasoline for many years. The earliest American steam machine of the present era was that built by the Stanley brothers in 1897. This machine is still being manufactured despite the fact that others who started out with the steam drive have given it up for the internal combustion engine.

The history of the gas vehicle properly starts with 1860, when Lenoir in France patented a vehicle driven by an explosive engine. In this country the first man was George B. Selden, who began experimenting with power-driven vehicles in 1874. Realizing that the steam engine was entirely too heavy for his purpose, he endeavored to produce a gas engine. At first he generated gas by burning liquid fuel, and tried to utilize this gas in the cylinder of the engine just as steam is used. But he soon found that this was not practical, and finally decided that the combustion of the gases should take place in the cylinder itself. About this time he came across the work of Brayton, who was building internal combustion engines for boats. Brayton's work covers the years from 1870 to 1885, and he did much pioneer labor on a type of engine that is now obsolete. Brayton's idea was to compress the gas and ignite it as a jet in the cylinder. Having built a model and having satisfied himself that he was on the right track, Selden applied for a patent in 1879. But although Selden was undoubtedly the first man in this country to invent a gasoline automobile, he was not a pioneer, for he did

The Stanley brothers in their first car. The pioneer of modern American steam vehicles.



The first successful American gasoline car; built by Duryea in 1892-1893.

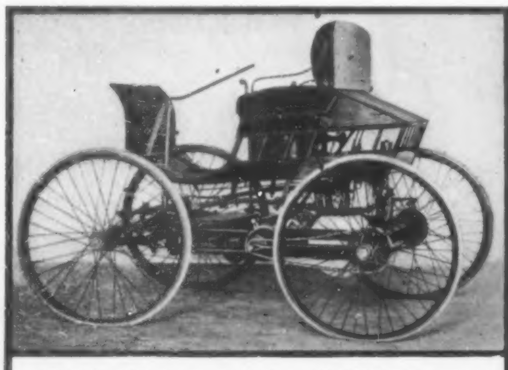


Charles Duryea in his famous machine that won important races here and abroad in 1895 and 1896.

not show the way to others. Instead, he kept his patent pending in the Patent Office by various means for sixteen years. Not until 1895 was the patent issued and the public apprised of the early work of George Selden, by which time the automobile had been well established and was being manufactured here and abroad. The patent added nothing to the knowledge that other investigators had acquired by the labor of their own hands. Instead of a public benefit it proved a public loss; it served merely as a pretext for exacting tribute from automobile manufacturers.

In 1905, ten years after the issue of the patent and a quarter of a century after its inception, was the first and only Selden car built, and then its only purpose was to prove the validity of the patent. Finally, in 1911, when the patent had but a few more months to run, the decision was rendered that the modern car is not an infringement of the Selden patent, because it does not use the Brayton type of engine, but that of Otto. The latter dates back to 1878, and hence was known at the time that Selden filed his application.

About the time that Selden was making his early experiments, Siegfried Markus in Austria built a gasoline-propelled vehicle which is still on exhibition in Vienna and bears date of 1877. However, there is no evidence that it ever ran.



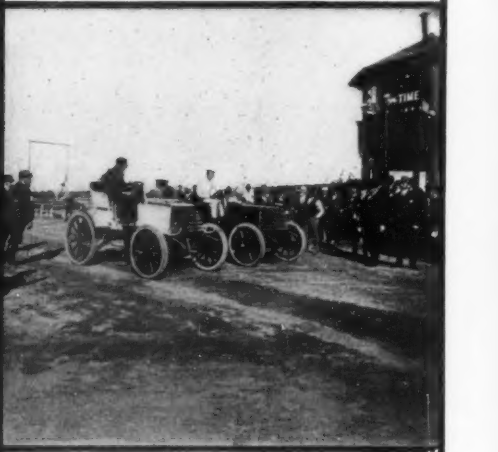
The first Haynes car that ran in 1894 and won a prize for design in 1895.

R. E. Olds's first departure from steam to gasoline. Begun in 1894 and finished late in 1895.

Charles B. King steering his power buggy driven by a marine engine (1894).

First Winton car sold (1898). Note the pins to prevent boys from stealing a ride.

The car of F. B. Stearns, built in 1896, and still in good running condition.



Race at Guttenberg, N. J., in 1900. Two Panhard-Levassor machines competing.

The real father of the modern automobile was Gottlieb Daimler, who, in 1884, patented a road vehicle driven by a high-speed internal combustion engine of four-cycle type. A year later Karl Benz, also of Germany, produced a vehicle driven by an internal combustion engine. These, the first steps in the development of the modern automobile, took place in Germany. At first progress was slow, but inside of ten years the motor-propelled vehicle had proved itself of sufficient popular interest to cause the *Petit Journal* to offer a prize for an automobile race from Paris to Rouen. This was in 1894, and it proved a great success. The next year another race was held between Paris and Bordeaux, in which there were sixty-six entrants.

In the meantime America was not standing still. Indeed, in the earliest days of the present era of automobiling this country was very proudly represented. Despite the prior invention of Selden, we may point to Charles E. Duryea as the father of the American automobile. He started out at first with the idea of building a flying machine. It was in 1886, at the Columbus (Ohio) State Fair, that he came across a gas engine. It used gasoline for fuel and had electric ignition, using twelve wet cells. Mr. Duryea tells us it weighed a ton at least and was as big as a dinner table, while the gas tank, which was the equivalent of the carbureter, was as big as a washtub. Beautiful as this machine looked to Mr. Duryea, it was evidently not adapted for flying, but it occurred to him that it would make a good horse, and so he decided to build a motor-propelled road vehicle. Realizing that the public was hardly ready for such a machine, he did not actually start work until several years later. It was in the fall of 1891 that he began the construction on his first motor carriage. The following spring it was completed and actually ran. This encouraged the building of a second and a third machine. The last was a big success. Although Lenoir in 1862 used a jump spark, all the other foreign machines up to 1895, and some as late as 1900, used the hot tube ignition. Charles Duryea, with his brother, Frank Duryea, however, used spark ignition, and they developed the spray carbureter in the very first machine, while the foreign machines for five or ten years longer used a surface or bubbling device. Even the bloc motor was used by Duryea in 1894 and the throttle control was developed in 1895-1896. But we must drop this pioneer for the time being and consider several others.

Elwood Haynes started work upon a power-driven machine in 1893. He used a two-cycle marine-type gasoline engine that weighed 180 pounds and gave only one brake horse-power. When the machine arrived it was set up in Mr. Haynes's kitchen and put to a test. It operated with such speed and vibration as to pull itself from its attachment to the floor. This showed Mr. Haynes that he would have to build a vehicle of much heavier construction than he had at first contemplated. It was not until July 4th, 1894, that the machine was ready for test. Then, because of the crowds that gathered around the curious vehicle, it had to be hauled three miles into the country behind a horse and carriage. But it came back under its own power at the goodly speed of 7 miles an hour.

Another pioneer who began in 1893 is Alexander Winton, but his first product was a motor bicycle. It was not until 1895 that the first Winton gasoline machine was completed, and it was a curious looking car, being designed for four passengers, the two seats being placed back to back. This machine made many successful runs in Cleveland during that year. In the meantime, R. E. Olds was not idle. As previously stated, he built his first machine in 1887. This, however, was a three-wheeled steam machine, although gasoline was used for fuel. A four-wheeled steamer was built after that. Finally, in 1894, he started the construction of a gasoline vehicle.

In the same year two other pioneers appeared. Charles B. King, a manufacturer of marine gasoline engines, placed one of his engines in his buggy and gave his horse a holiday while he chugged about Detroit in his motorcar. Henry Ford, who built a steam vehicle in 1892, started a gasoline machine in 1894. But he was not building cars as rapidly then as he is now. Not until 1896 was that machine completed. In the same year Frank B. Stearns completed his first automobile and also built two others, which were sold.

America in the early days was no more kind to the horseless carriage than it has been to the flying machine. For the first ten years only two patrons of the automobile appeared. Inspired by the successful races abroad, and endeavoring to stimulate interest here, the Chicago *Times-Herald* offered prizes amounting to $5,000 for a 92-mile race to be held in and about Chicago on the Fourth of July, 1895. This generous offer was enough to take the breath away from American inventors. They were totally unprepared for it, and time and time again the race had to be postponed because, although on paper there were enough entrants, not enough machines materialized to make it a real race. Not until November 2nd was a contest held, and this was merely a consolation race, because there were but two competitors, namely, one Duryea machine and an imported Benz car. Unfortunately the Duryea machine, although leading, was purposely ditched, to avoid collision with a farm wagon that made a false turn on the course, and the German car struggled on alone to the finish. Finally, Thanksgiving Day was set for the real race, and five cars participated. Of these, two were Benz cars and one a Roger from France, while America was represented by a Duryea and a Sturges electric car. The course was a most difficult one because a snowstorm had covered the ground with twelve inches of snow. One of the entrants was the Haynes car, which won a prize for the best design of motor, but did not actually engage in the race because of an accident due to skidding on the ice just before the start. Only two of the contestants finished this race, and they were the ones that had engaged in the consolation race a few weeks before. This time, however, the Duryea car won easily, leaving the Benz far in the rear.

The second big race was held the following year on Decoration Day. The prizes, amounting to $3,000, were offered by Mr. John Brisben Walker of the *Cosmopolitan Magazine*. The course was from City Hall, New York, to Irvington-on-the-Hudson and return. Four Duryeas were entered in this race and they won every prize.

It was in the fall of 1896 that the English Parliament repealed the restrictions to motor traffic on British highways, and the same day, November 14th, a race was held in celebration of this event, between London and Brighton, a distance of 52 miles. There were entrants from all countries, France and Germany being well represented. It was naturally expected that the winners of the Paris-Bordeaux contest would sweep

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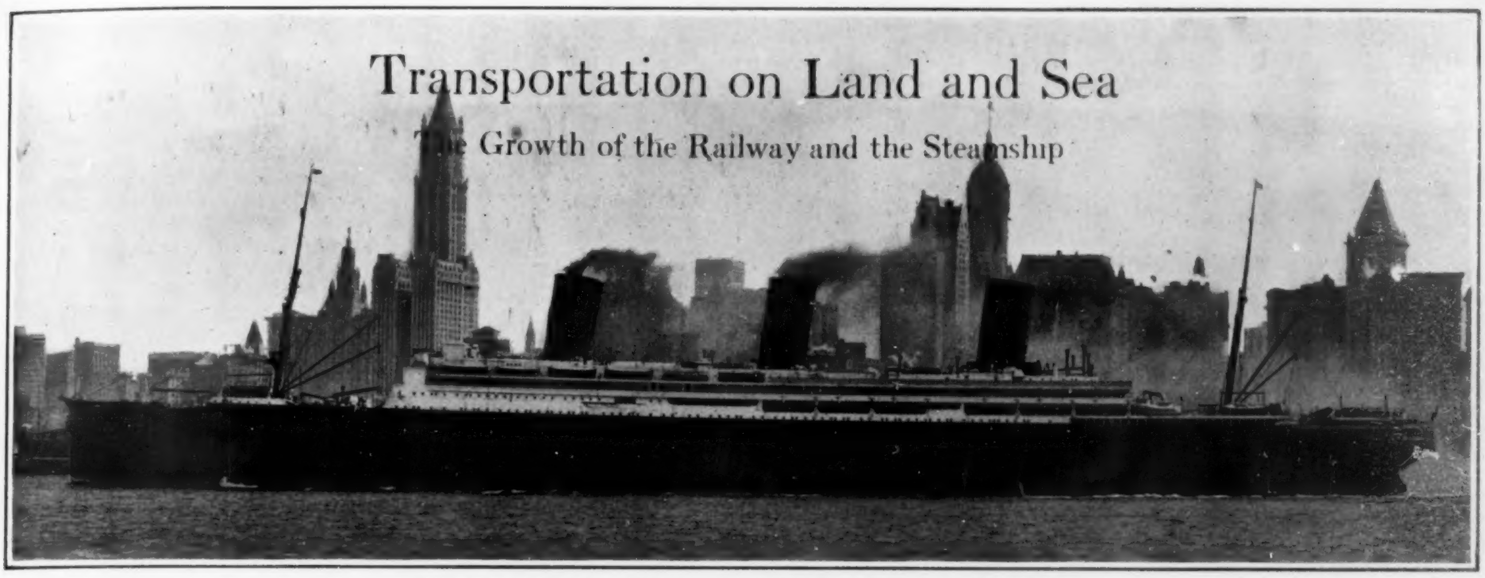


The nine hundred and nine foot "Imperator" steaming up the Hudson River.

Development of the Transatlantic Steamship.

ON July 4th, in the year 1840, a little wooden side-wheel steamer cast loose from her dock at Liverpool, and fourteen days and eight hours later steamed into Boston harbor amid the acclamations of the assembled citizens and every manifestation of civic pride and rejoicing. The little craft was the "Britannia," the first of the since-famous Cunard Line, and the first steamer to sail under regular government contract for the conveyance of the transatlantic mail. In the accompanying diagram, showing the growth of the transatlantic steamship during the seventy years covered by the life of the SCIENTIFIC AMERICAN, we commence with the "Britannia" for the reason that, although she was not by any means the first steamship to cross the Atlantic, she was the first to do so on a regular schedule.

The "Britannia" was a wooden side-wheel steamer 215 feet long, 34 feet 4 inches in beam, and of 1,731 tons displacement. Her engines, of 740 horse-power, gave her an average sea speed of 8.5 knots. She was one of four sister steamships built under a contract with the British government, by which the company was to provide four steamers and dispatch one of them from Liverpool for Halifax and Boston, on the 4th and 19th of every month from March to October, and on the 4th of each of the four winter months. At the date of the birth of the SCIENTIFIC AMERICAN, therefore, these ships were representative of the Atlantic steamship of that day; and the illustration which we give of the "Aquitania" of 1914, carrying all four of these little craft on her boat deck, which she would be quite capable of doing, may be taken as an excellent epitome of the past seventy years of development. The "Aquitania" is 901 feet long by 97 feet broad and is 92 feet deep from keel to topmost deck. Her displacement is something over 50,000 tons, and with 60,000 horse-power she has made a speed of 23.5 knots.

Mention should be made of the fact that in the first decade covered by the present review, that great engineer, Brunel, built the first iron steamship, also named "Britannia," in which he anticipated many of the improvements which were to come in later years. Brunel's "Britannia" had a double bottom and transverse and longitudinal bulkheads. She was the first ship to employ the screw propeller, and in other details in addition to these she was pre-eminently the pioneer of the modern ocean liner.

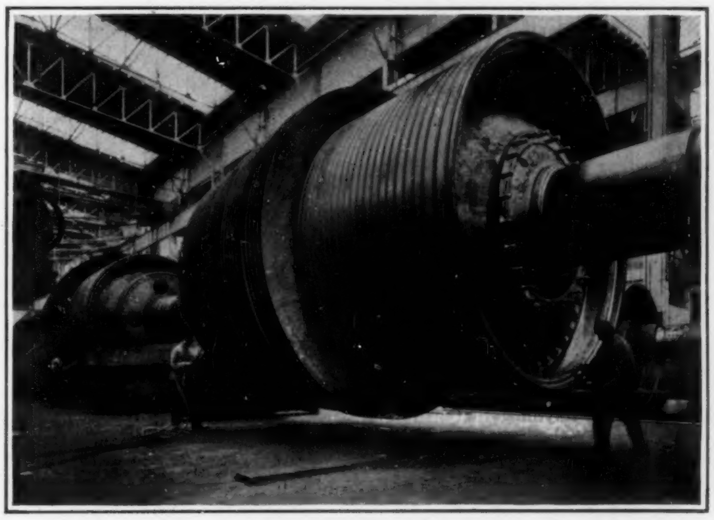
The first American steamer to be built for the Atlantic trade was the "United States," constructed in New York by William H. Webb for the Black Ball Line of packet ships. She made her first voyage to Liverpool in 1847 and it lasted thirteen days. She was a wooden ship of 2,000 tons burden, 256 feet long by 50 feet beam.

In 1850 the United States entered the lists against the Cunard Company by putting in service four boats of the Collins Line, vessels which in size, speed, luxurious accommodations and general excellence of finish were in advance of anything afloat at that time. The "Pacific" of this line was the first ship to make the passage from New York to Liverpool in less than ten days, which she did during a passage in May, 1861, bringing the time down to nine days, twenty hours, sixteen minutes. In February of the next year the "Arctic" crossed in nine days, seventeen hours, twelve minutes. The same company in 1855 launched the "Adriatic," a vessel of 4,144 tons.

To meet the successful competition of the Collins Line, the Cunard Company in 1855 launched the "Persia," of 3,870 tons and about 14 knots speed. She was a paddle steamer and was built throughout of iron.

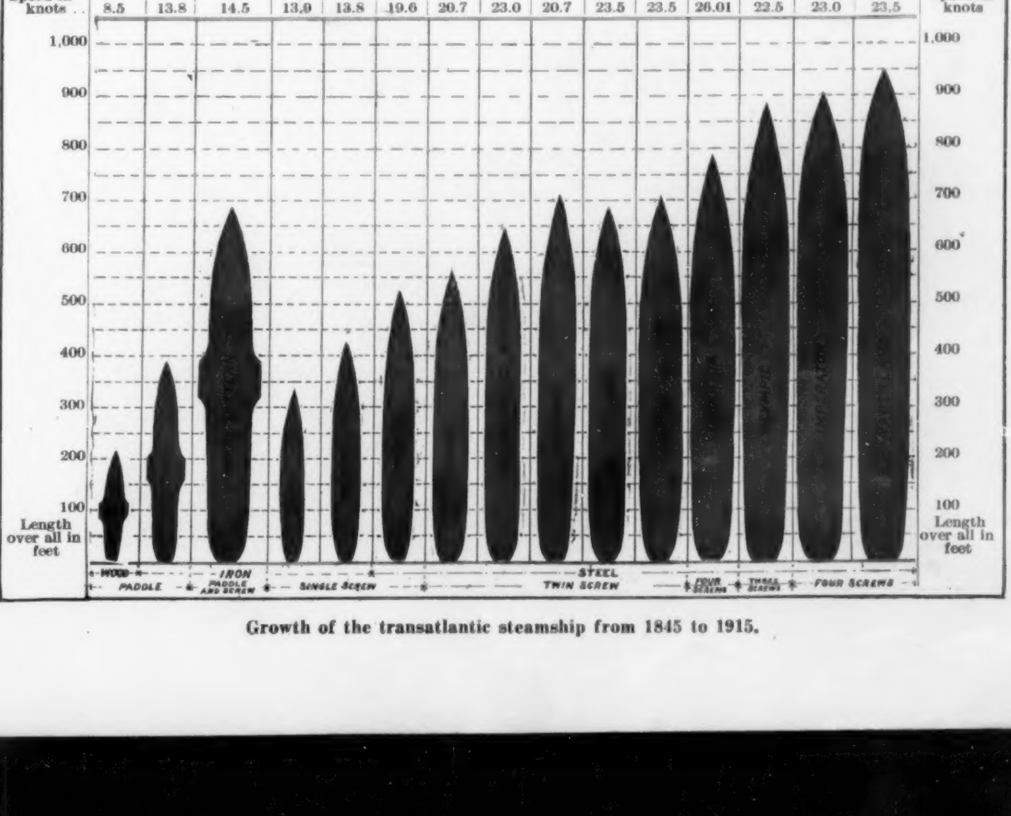
We have introduced into our diagram a phenomenal vessel which, strictly speaking, should not have any place in the history of the development of the transatlantic mail steamer, for the reason that she was never run on any regular schedule under government contract. We refer to the "Great Eastern," and she is shown in order to emphasize the fact that she was fifty years ahead of her time and, in fact, anticipated in point of size such vessels as the modern "Oceanic" and "Kaiser Wilhelm II."

The "Great Eastern" was a splendidly built ship, and cost no less than $3,650,000, an enormous sum in those days. She was 692 feet long on deck, 118 feet broad over the paddle boxes, and she displaced 28,000 tons on her ordinary draft, although on a draft of 30 feet she would displace 32,160 tons. She was driven both by paddle wheels and by a screw propeller. Her maiden trip was made from Liverpool to New York in 1860. Her highest speed during the trip was 14½ knots an hour and the longest day's run 333 miles. The ship was the safest passenger vessel ever built, including even those of the present day. She had a complete double hull, extending to 10 feet above the waterline, where she carried a water-tight deck, and she was divided longitudinally and



The rotor of one of the low-pressure turbines of the "Imperator." Diameter, 18 feet.

Date	1840	1855	1858	1862	1874	1884	1889	1897	1899	1900	1903	1906	1911	1913	1914	Date
Length on deck	215′	385′	692′	337′	435′	525′	560′	649′	705′	686′	707′	790′	883′	909′	950′	Length on deck
Beam	34′ 4″	45′ 3″	83′	40′ 5″	42′ 3″	57′ 3″	63′	66′	68′	67′	72′	88′	92′ 6″	98′	100′	Beam
Displacement in tons	1,731	4,950	28,000	3,808	6,834	12,190	15,000	21,000	29,000	23,500	27,000	44,500	52,000	54,000	58,000	Displacement in tons
H. P.	740	2,900	8,000	2,250	3,250	14,500	20,000	31,000	28,000	37,500	38,000	70,000	60,000	70,000	80,000	H. P.
Speed in knots	8.5	13.8	14.5	13.9	13.8	19.6	20.7	23.0	20.7	23.5	23.5	26.01	22.5	23.0	23.5	Speed in knots



Growth of the transatlantic steamship from 1845 to 1915.

transversely by bulkheads which gave her a total of fifty compartments that were water-tight. She was many years ahead of the development of passenger and freight traffic, and could never secure sufficient of these to render her a paying investment. She proved invaluable, however, by successfully laying the first Atlantic cable in 1866, and she laid two others in 1873 and 1874. Finally, in 1888, she was sold and broken up at Liverpool.

For several years the Inman, now the American Line, had been using the screw propeller, and in 1862 the Cunard Company launched the screw-propelled "China," a vessel 337 feet long, whose average transatlantic speed was 13.9 knots.

About this time the compound engine, with its higher steam pressure and superior economy, began to make its appearance, and simultaneously came in that era of long and narrow ships which was destined to play such an important part in the history of the steamship. The "Bothnia," 1874, was a compound, single-screw vessel, which was typical of the ships of that day. With a length of 435 feet, her beam was only 42 feet 3 inches—a ratio of length to beam of over one to ten. Her speed was about the same as that of the "China."

Within the next ten years there was a steady increase in dimensions, and in 1884 there appeared in service the "Umbria" and "Etruria," the crack ships of their day, 525 feet in length and displacing 12,190 tons. They were single-screw vessels, and their engines, the largest single-screw engines ever put into a steamship, indicated 14,500 horse-power. The "Etruria" maintained a speed of 19.6 knots for the whole trip across the Atlantic and she was the first transatlantic steamship to make the passage in less than six days.

The credit for producing the first twin-screw transatlantic steamers, the "City of Paris" and the "City of New York," is due to the Inman and International Line. These remarkably fine vessels, which are still in service, are 560 feet in length, 63 feet in beam, and they displace 15,000 tons. The "City of Paris" made the transatlantic passage at an average speed of 20.7 knots. The two vessels introduced many excellent features, one being their great beam in proportion to their length, and another the remarkably handsome dining saloon, placed forward of the engines, a disposition now universally followed.

In 1893 the Cunard Company took the leading position with two steamships which were the first to exceed 600 feet in length, the "Lucania" and "Campania." They were designed to be considerably the fastest vessels afloat, and to this end engines of 30,000 horse-power were provided. The "Lucania" was the first ship to cross the Atlantic at a speed of over 22 knots.

The North German Lloyd Company made a notable entry into the competition for the blue ribbon of the Atlantic by setting afloat in 1897 the "Kaiser Wilhelm der Grosse," 649 feet long, and of 20,000 tons displacement. She was a very handsome ship, and she was the first transatlantic liner to have four smokestacks.

In 1899 the White Star Company, whose vessels have always been justly famous for comfort and regularity, determined to build a first-class liner which should greatly exceed in size anything that had yet been constructed, and the result was the "Oceanic," the first vessel to exceed in length the "Great Eastern." The "Oceanic" was 705 feet long, 68 feet beam, and normally she displaced 28,000 tons. Her best speed was 20.7 knots.

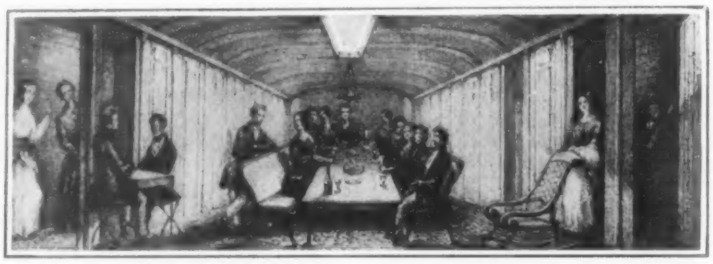
The Hamburg-American Line signalized its entrance into the contest for the blue ribbon of the seas by setting afloat in 1900 the "Deutschland," 686 feet long, and of 23,500 tons displacement. This vessel was equipped with twin screw, six-cylinder, quadruple-expansion engines, which on a voyage in which the "Deutschland" averaged 23.5 knots, gave a maximum indication of 37,500 horse-power. The North German Lloyd Company replied by building the "Kaiser Wilhelm II," a much larger vessel, 707 feet long and of 27,000 tons displacement, which with a maximum indication of 40,000 horse-power, also crossed the Atlantic at an average speed of 23.3 knots.

The very fine ships of the German company reached the high water mark of the development of the reciprocating marine engine, although in point of output the reciprocating engines of the "Olympic" in later years have equalled those of the "Deutschland" and "Kaiser Wilhelm II."

With the appearance in 1897 of the "Kaiser Wilhelm der Grosse," the blue ribbon of the Atlantic was captured by a German company, and it remained in their possession for a decade. In 1906, however, the Cunard Company, with the assistance of the British government, who loaned $13,000,000 at 2½ per cent interest for the purpose, set afloat the first high-speed transatlantic liners to be propelled by the steam turbine. These ships were the "Lusitania" and "Mauretania," 790 feet in length, 44,500 tons deep-draft displacement, whose turbines of 70,000 horse-power, operating four propellers, have driven both of these ships across the Atlantic at an average speed of slightly over 26 knots per hour. That speed has not since been approached, nor is it likely to be exceeded for many years to come. The shipowners claim that, were it not for the government assistance and the subsidy of $750,000 per year for carrying the mails, these ships, because of their enormous coal expenditure, could not be made a paying investment. This seems to be proved by the fact that all large and fast transatlantic liners built since the advent of the fast Cunarders, are of more moderate speed and, if we take into consideration their great size, of more reasonable coal consumption.

The next great advance in dimensions took place when the White Star Company built the "Olympic" and "Titanic." These vessels are 883 feet long, 92 feet 6 inches beam, and displace about 52,000 tons. The engine-room equipment is interesting, because of the fact that the steam is utilized first in two quadruple-expansion reciprocating engines of 38,000 horse-power, placed in the wings of the vessels, and from them exhausts to a large low-pressure turbine, driving a center shaft, which develops a shaft horse-power of 23,000. The great size of the "Olympic" made it possible to provide even more spacious accommodations than on the "Lusitania," and it was claimed for the "Lusitania" that the cubic space devoted to each passenger in the first-class accommodations was 50 per cent greater than that on any previous ship.

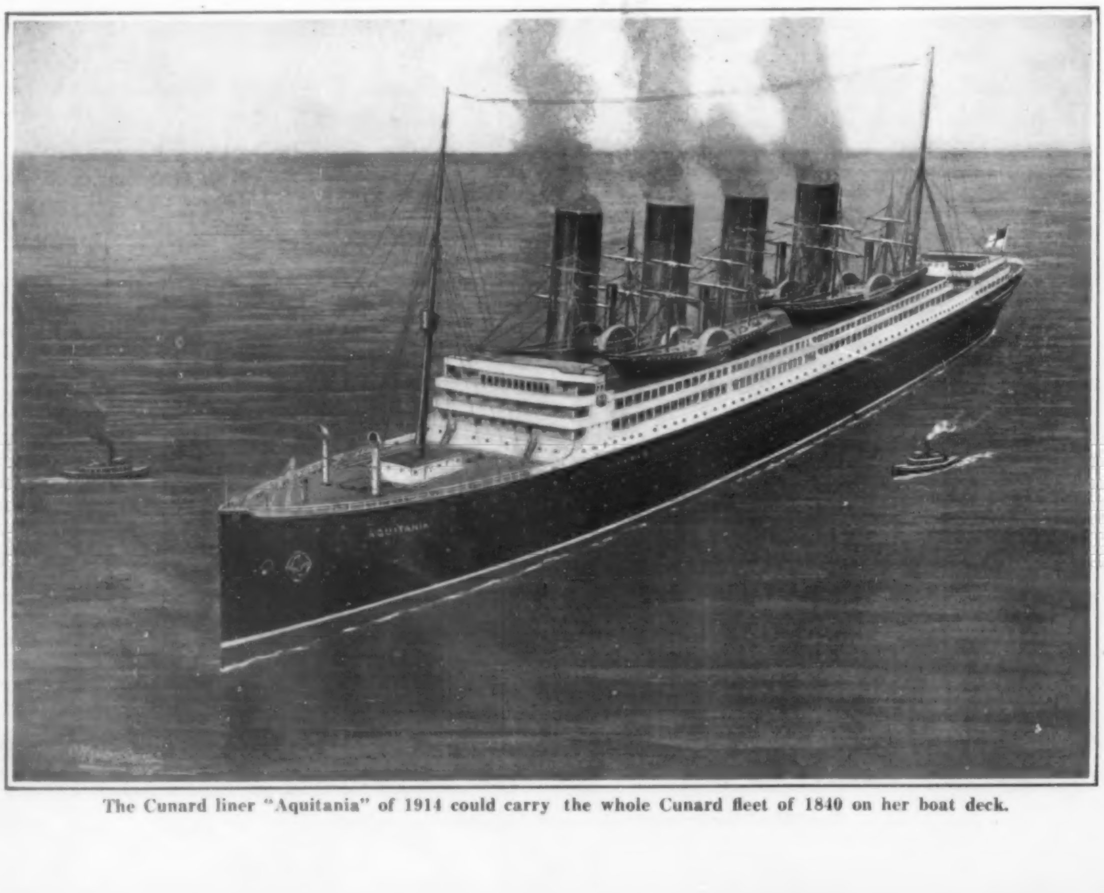
To the Hamburg-American Line belongs the credit for building the first ship over 900 feet in length. The "Imperator," which made her maiden trip in 1913, is 909 feet in length, with a beam of 98 feet and a displacement of 54,000



Dining-room and saloon of a steamer fifty years ago.

The first transatlantic liner of the North German Lloyd—or rather of its predecessor, the Ocean S. S. Navigation Company—was the "Washington," considered in its day a marine wonder. The cabins were entered from a central hall, about ten feet wide. This hall took the place of the dining-room and saloon of to-day. At meal time a table, running the length of the hall, was placed in position and about it the dozen first-class passengers partook of their repast. Upon its completion the table was folded up and then the "dining room" again became the "saloon." The records show that on her initial trip this "Washington" carried one first cabin and ninety-three steerage passengers!

Photograph showing the "Great Eastern" at the foot of Canal Street, North River, New York, in 1860.



The Cunard liner "Aquitania" of 1914 could carry the whole Cunard fleet of 1840 on her boat deck.

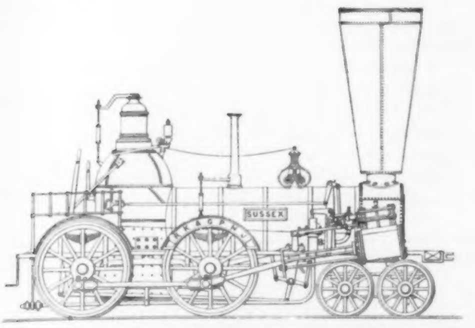


Fig. 1.—Engine with variable cut-off motion. 1845.

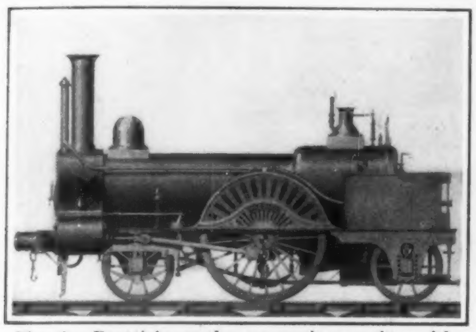


Fig. 3.—Beattie's smoke consuming engine with feed water heater. 1856.

tons. Her quadruple turbine equipment, with 60,000 shaft horse-power, has driven her at a speed of 22.5 knots. The following year the same company dispatched to New York a sister ship of larger size and greater speed, the "Vaterland." This enormous vessel is 950 feet long, 100 feet in beam, displaces 56,000 tons, and her turbines, of 75,000 horse-power, give her a transatlantic speed of 23.5 knots. The same year the Cunard Company put in service the "Aquitania," 901 feet in length, with a beam of 97 feet, displacing a little over 50,000 tons. Her model is finer than that of the "Imperator," and with 60,000 horse-power developed by her turbines she has made a speed of 23.5 knots.

The growth in size and comfort of the transatlantic steamship has been accompanied by an equally steady improvement in the motive power. The decade 1845 to 1855 witnessed the substitution of iron for wood, and during that period the approximate boiler pressure rose from 10 to 20 pounds per square inch; the approximate consumption of coal per horse-power per hour dropped from 4.5 to 3.5 pounds. From 1855 to 1865 the screw propeller took the place of the paddle wheel, the boiler pressure rose from 20 to 35 pounds, and the fuel consumption was reduced from 3.5 to 3 pounds. In the following decade, 1865 to 1875, the compound took the place of the simple engine and boiler pressure rose from 35 to 60 pounds, the coal consumption dropping from 3 pounds to about 2.5 pounds per horse-power per hour. In the decade 1875 to 1885, steel took the place of iron and the triple-expansion engine was introduced; the boiler pressure rose from 60 pounds to 125 pounds and the fuel consumption dropped from 2.5 pounds to 2 pounds. In the next decade, 1885 to 1895, twin-screw propulsion was introduced, as was also quadruple-expansion and the use of forced draft. Steam pressures rose from 125 to 200 pounds per square inch, and the coal consumption dropped from 2 to 1.5 pounds. In the decade 1895 to 1905 there was introduced experimentally the steam turbine. The work done by this type of engine in smaller vessels for cross-channel service and in one or two large ocean steamers paved the way for the introduction of the turbine during the next decade in the largest ships. A coal consumption of 1.3 pounds was reached by the large quadruple, six-cylinder engines which were the prevailing type in the fast transatlantic steamships, and the steam pressure was carried up to as high as 225 pounds. The decade of 1905 to 1915 witnessed the passing of the reciprocating engine and the substitution of the steam turbine. Although at first high boiler pressures were maintained, latterly it was found that lower pressures gave better results, and from 160 to 175 pounds is used on some important turbine-driven ships. The coal consumption dropped somewhat, but not as much as had been predicted, the best results showing a consumption of about 1.2 pounds per horse-power per hour.

The Development of the Steam Railroad.

Somebody has recently defined the present war in Europe as an engineers' war. It certainly is; and this for the reason that the age we live in is essentially, first and last, an engineers' age. Eliminate the work of the civil and mechanical engineer from the past seventy years, thoughtful reader, and you will realize at once that you have eliminated 90 per cent of those comforts, conveniences and broad practical achievements that make the present the wonderful age which it is.

If we were asked to name the one field of his activity in which more than any other the engineer has rendered possible the present material advancement of mankind, we should be tempted to name that of transportation. There is a broad sense in which we may say that the struggle of man up to an ever higher civilization is a fight against physical inertia—the inherent tendency of things to remain what they are and stay where they are.

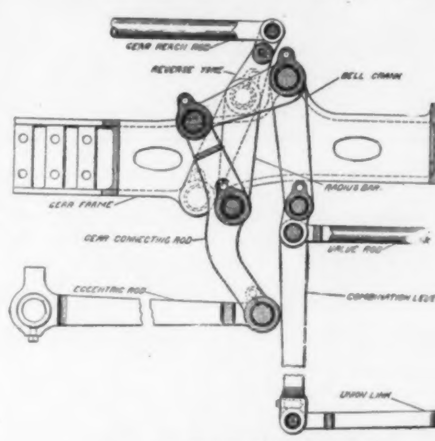


Fig. 5.—The Baker valve motion.

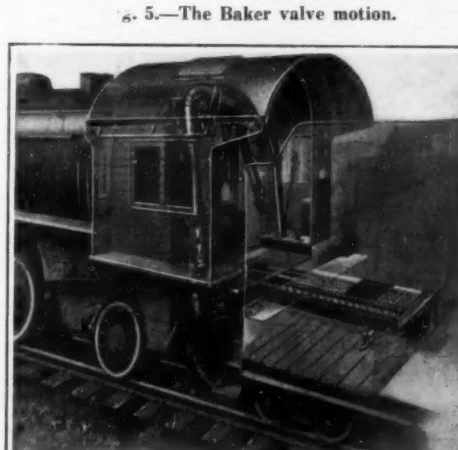


Fig. 6.—Street's mechanical stoker. 1915.

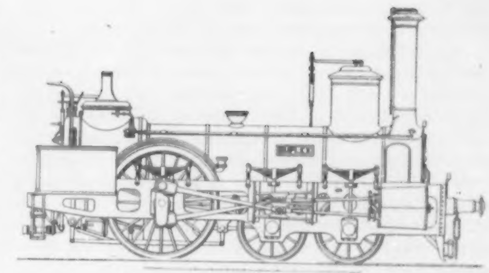


Fig. 2.—Haswell's four-cylinder engine. 1861.

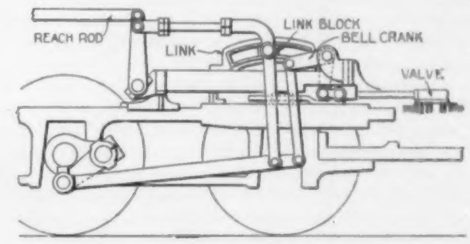


Fig. 4.—The Southern valve gear.

Transportation, then, as represented by the railroad and the steamship, lies at the very foundation of those marvelous developments of manufacture and commerce, with their resultant comforts and conveniences, which, during the seventy years covered by the life of the SCIENTIFIC AMERICAN, have been so great as to more than equal all previous advancement in the practical arts throughout the history of mankind. Thus, in the case of the great steel industry: Nature had provided vast stores of coal in one part of the North American continent, equally abundant stores of iron ore in another district, and elsewhere the necessary limestone. But without the transportation facilities afforded by the steamers of the Great Lakes and the steam railroad, we would possess to-day no great center of the steel industry, such as exists at Pittsburgh, nor any means of distributing the various products of its steel mills swiftly and economically throughout the whole world. Again, had the railroad and the steamship never been developed, it is safe to say that the greater portion of the wheat lands of the country would be still wild prairie, its forests would be uncut, its wealth of minerals scarcely touched, and the inertia of nature would still weigh heavily upon the land. The American railroad is as distinctively American as is our agricultural machinery. The early development of European railroads took place under exceptionally favorable conditions, for the population was dense and capital for construction work was plentiful. In Europe the population preceded the railroad, but in America it followed the railroad; in fact, it would be not stretching the point too far to say that throughout the greater part of the United States the railroad has been the pioneer of civilization.

Because of these conditions, it was possible to build the early European railroads upon a scale of solidity and excellence, which was impossible in the United

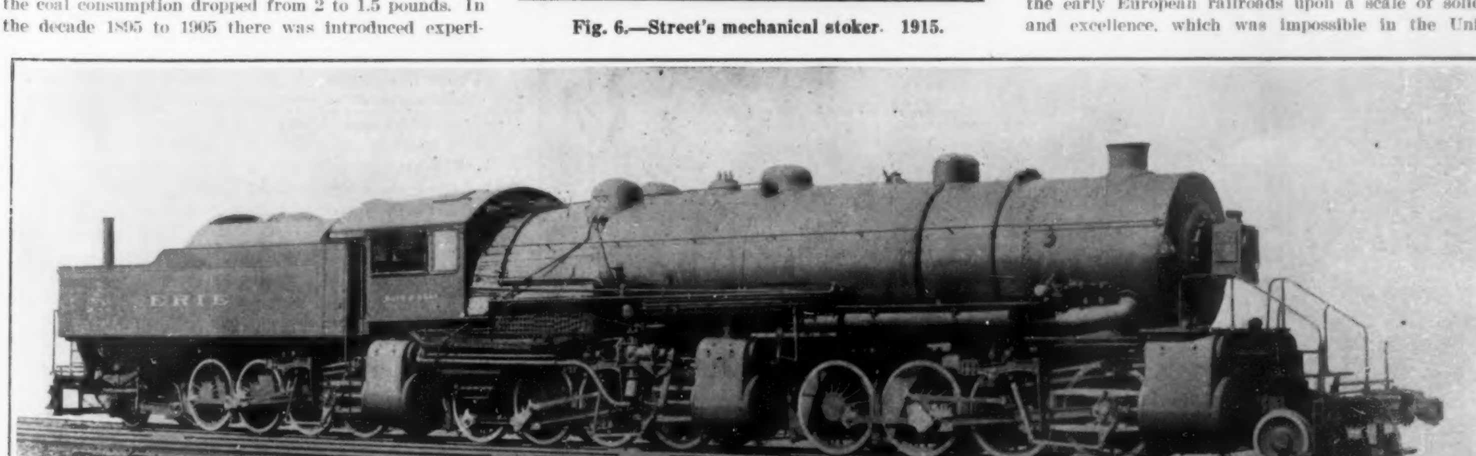


Fig. 7.—The Erie "pusher," largest locomotive in the world.

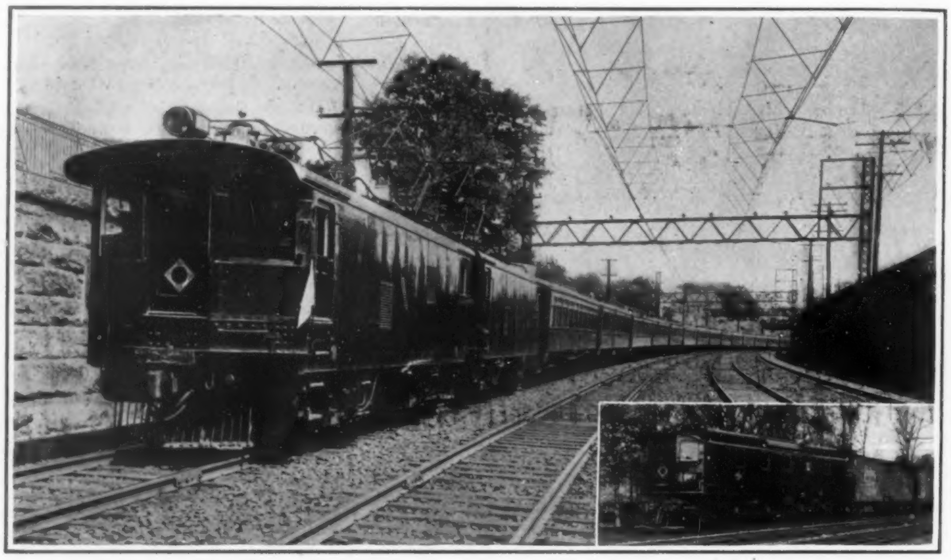
States at the same date. One of the most creditable features of our early railroads was the ingenuity shown by our engineers in building the roads to suit at once the topography of the country and the limited capital which was available for construction. In laying out the lines the locating engineer endeavored to reduce the amount of cutting and embankment to a minimum; and hence he did not hesitate, at the expense of greater distance and sharp curvature, to run his line around a hill in preference to tunneling through it. Steel suitable for bridgework was scarce and costly; but the forests of America provided unlimited stores of fine structural timber. In place of building a costly steel viaduct or solid embankment across a ravine or narrow and steep-sided valley, the American engineer erected timber trestles, and did not hesitate to span broad rivers with trussed bridges of timber of a length which had never been approached in the history of wooden bridges.

The railroad and track of 1845 were of simple and cheap construction. The rails weighed from 40 to 50 pounds per yard, the ties were small, and more often than not they were laid directly upon the graded ground without the interposition of gravel or broken stone ballast. But as the population increased and manufacture and commerce multiplied and dividends became more plentiful, there was a contemporaneous improvement in the roadbeds and the rolling stock. With the Bessemer process there came the steel rail—harder, stiffer, and more durable. Steel also took the place of timber in bridge construction; and as funds became available the engineers were sent out over the line to re-locate them, reducing the heavy grades, easing up the curvature, eliminating trestle work in favor of solid embankments, thus bringing the roadbed and track up to the level of modern practice. Some of our great systems, such as the Pennsylvania and the Union Pacific, in the last decade and a half have spent from forty to sixty millions of dollars in the mere improvement of the roadbeds, this big outlay being based upon the now-well-understood fact that the easier the curvature and the lighter the grade, the larger is the paying train load that can be hauled per locomotive and per a given size of train crew.

In pursuance of this policy, as soon as it was demonstrated that the saving in fuel and maintenance and the economies in the wages of train crews would exceed the fixed charges on the outlay necessary for the improvement of the roadbed and track, the work of reconstruction has been put in hand. Consequently, where the traffic is sufficiently heavy to guarantee the change, our railroads have been brought fully up to that of the best European practice.

It may come as a surprise to some of the readers of the SCIENTIFIC AMERICAN to learn that practically the whole of our vast railroad system, now totaling 253,000 miles, has been built during the life of this journal. Thus, in the year 1845 there was in the whole United States only 4,633 miles of road, which was made up of a small number of disconnected lines to be found in the Atlantic and Southern States, and a few fragmentary systems located in the Middle States. That year the eastern railroads were commencing to creep across the Alleghenies into the Mississippi Valley; but as yet there was no indication pointing to the development of a through trunk line.

Tracing the development of the railroad by decades, we find that from 1845 to 1855 the total length of all railroads grew from 4,633 miles to 18,374 miles. By 1865 the total had reached 35,085 miles, and ten years later it was 74,096 miles. In 1885 it had risen to 128,320 miles and the lapse of another decade brought it up to 180,657 miles. At the opening of the twentieth century the 200,000-mile mark had been passed, and in 1905 the total length of all railroads was 218,101 miles. In 1913 the most reliable statistics credit the country with a total of 249,802 miles, and the latest figures available, those for 1914, show that our railroad system has reached the stupendous total of 253,000 miles.



Electric passenger and freight trains on the New York, New Haven & Hartford Railroad.

A notable event, and surely the most epoch-making, was the completion on May 10th, 1869, of the first trans-continental road across America, the Union Pacific.

The distinctive American passenger car, with its long body carried upon end swiveling trucks, was patented by Ross Wynans in 1834, and by the year 1845 it was well established as the typical American car. The passenger car in those days was from 9 to 10 feet wide, 45 to 50 feet long, and it carried about sixty passengers. It was lighted by oil lamps and warmed in winter by a wood-burning stove, both of these being frequent causes of fatal fires when the all-too-frequent collisions occurred. The improvements in car construction of the past seventy years have been in the direction of comfort, strength and safety. First, there came the abolition of the oil lamp and the introduction of Pintsch gas; the dangerous wood or coal stove was abolished and the trains were heated by steam taken from the engine. Finally, during the past two decades, there has been a gradual substitution of steel for wood as the material of construction, a change which has contributed greatly to the lowering of the death rate in collisions and other train accidents.

The great distances between important cities and the ever-increasing length of railway journeys led to the introduction of the sleeping car, and in 1864 Pullman brought out his first sleeper, which was known as the "Pioneer." Shortly thereafter the Pullman Company was organized and, mainly due to its efforts, the sleeping car has been brought up to its present standard of strength and comfort.

Of all the improvements in railroads designed to expedite travel and promote the safety of both passengers and freight, by far the most important are the automatic air brake and the block signal system. Limitations of space do not admit of more than a passing reference to these. The continuous automatic airbrake, named after its designer, George Westinghouse, Jr., was first put into practical service on a trunk line railroad in 1868 to 1869. By means of this system of control, the engineer in his cab, by means of a lever, can instantly set the brakes in every car throughout the train and on his own engine; moreover, should the train break apart, the brakes will automatically set themselves. The simplicity of operation, the enormous power of this brake, and the certainty with which it operates render it one of the most successful inventions of any age. In the Burlington brake trials held in 1886 to 1887, a train of fifty freight cars, running at 40 miles an hour, was stopped in a distance measuring a third of its own length. The improvements in the airbrake during the past twenty-five years are shown by the following comparisons:

A train in 1890, weighing 280 tons and going 60 miles an hour, even if it were equipped with the best airbrake of that day, could not be stopped in less than 1,000 feet. A train in 1915, weighing 920 tons and going 60 miles an hour, has an energy in foot-tons nearly four times as great as that which had to be dissipated in stopping the train of 1890. With the 1890 brakes the 1915 train could have been stopped in perhaps 1,760 feet, but that same 1915 train, with the improved electro-pneumatic Westinghouse airbrake, can be stopped in 860 feet.

The block signal system, the greatest of all preventers of railroad collision, has seen a gradual evolution from the time when the crude idea was first entertained and acted upon. In 1845 there was practically no block signaling in this country, even in an embryonic form. The development of block signaling is to be credited to Europe, and mainly to Great Britain, in which country, as far back as the year 1890, 98.5 per cent of the English railroad lines were equipped with block signals. Under this system, in the operation of trains, no two trains are allowed upon the same "block" or section of line at the same time; in other words, the trains are kept apart by space instead of by time.

The Pennsylvania was the first to make extensive use of the system, which it did in 1864. In 1886 the Canadian Pacific advertised that it made use of the block signal system. America's contribution was the introduction of automatic signals, in which the train, through an electric circuit through the rail, operates its own signals and safeguards itself automatically. Automatic signals were first used in America in 1871 on the Eastern Railroad in Massachusetts, and the first automatic signals using the now universal track circuit, were used in Massachusetts in 1879.

Some will consider that the automatic stop, the latest improvement in connection with block signaling, is the most important safety device of all. It consists in tying the signals in with the moving train, in such a way that if an engineer runs by a signal, the signal itself will automatically set the brakes and stop the train. The most brilliant success has attended the installation of the automatic stop on the New York subway. Here the express trains are run at 40 miles an hour under a headway of less than a minute and three quarters.

(Concluded on page 558.)

The first electric train of the New York Central leaving the Grand Central station, New York city, on September 30th, 1906.

Seventy Years of Civil Engineering

Retrospective Review of the More Important Works Completed During the Life of the Scientific American

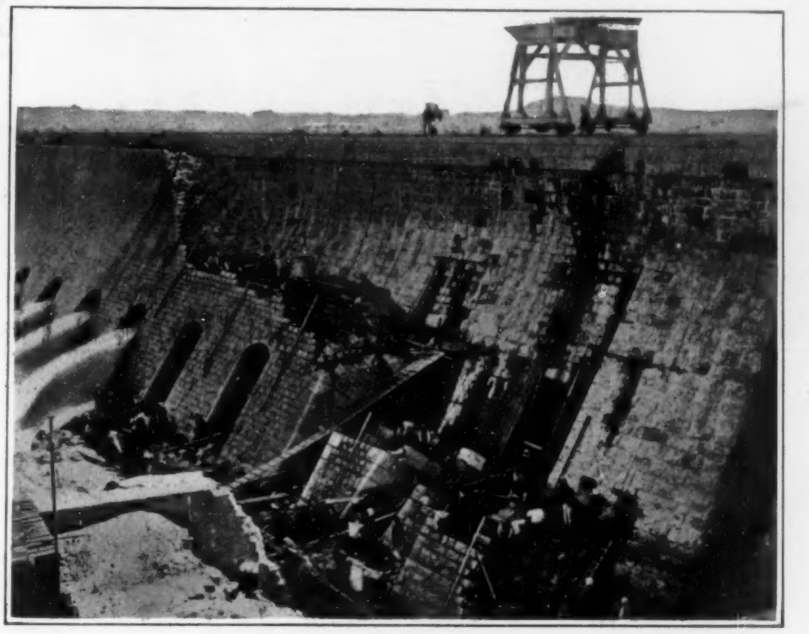
THE story has been told of a monarch who once asked a civil engineer what was the limit of the constructive ability of his profession, and he answered, "Give me sufficient money, men, and time and I will accomplish anything." There is just enough of truth in this to cause us, when we contemplate the engineering works of the present day, to hesitate before we say: This is final. The Panama Canal, the Forth Bridge, the Aswan Dam, the Catskill Aqueduct, and all such works of magnitude are after all but the pledge and promise of greater things to come. The civil engineer, by continually providing improved methods of transportation, and making available nature's stores of crude material, enables the great mechanical industries to provide him with larger and better tools with which he is increasingly able to exceed the great performances of the past.

It is impossible within the limits of this article to give much more than an encyclopedic review of the vast field of civil engineering during the past seventy years—we can do no more than touch upon the high points in the vast field that is opened up to retrospective analysis.

Water Supply and Irrigation.

The art of impounding water and distributing it by canal and aqueduct for the use of farm and city is as old as history itself; and, at the period of the birth of the SCIENTIFIC AMERICAN there were scattered throughout the world many modern and important reservoirs which differed, not in principle, but merely in magnitude, from the great works of the present day. A typical system was that known as the old Croton Dam with its aqueduct leading from the valley of the Croton River to New York, which was opened about the time that this journal came into existence. After some fifty years of service it was realized that the supply of water from the Croton reservoir would soon be insufficient for the needs of New York, and the great structure known as the new Croton dam was commenced in the early nineties. This handsome structure stands today as one of the greatest masonry dams in existence. It is built of solid masonry and its foundations which lie, at the lowest point, some 140 feet below the bed of the river, extend up and down stream 200 feet, while above the mass of masonry rises to a height of about 300 feet. The total length, including the spillway, is 2,168 feet, and the total amount of water impounded is seventy billion gallons. The new and old aqueducts leading from the reservoir, together with other local sources of supply, made it possible to deliver nearly four hundred million gallons of water per day to New York city.

The Croton reservoir had not been long in operation before the rate of increase of population of Greater New York was so rapid as to render urgently necessary the preparation of plans for a fresh supply. It was determined to bring in the mountain water from the Catskills, and to this end a solid masonry dam known as the Olive bridge dam was built across the valley of the Esopus, forming the Ashokan reservoir, whose capacity is 132 billion gallons. The dam is 192 feet thick at the base and 220 feet high. The water is conveyed to New York city by an aqueduct from 14 to 17 feet in diameter, which extends for a distance of ninety miles. At the northern limits of New York the aqueduct drops to a deep tunnel, which is carried everywhere in rock throughout the full length of Manhattan, at depths varying from 300 to 750 feet. At intervals shafts rise to the surface, and from these the water is distributed by steel pipe mains. A branch tunnel passes under the East River to Brooklyn, where the aqueduct is continued to the Narrows, under which it is carried by pipes laid in the bed of the channel for the service of Staten Island. The work, which is approaching completion, will cost $170,000,000, and it will provide New York with an additional daily supply of 500,000,000 gallons.



Increasing the thickness and height of the Aswan dam, Egypt.
Capacity, 82,000,000,000 cubic feet.

Another great water supply scheme in the United States is that for the service of Los Angeles. The water is conveyed from the Sierra Mountains by means of an aqueduct which is partly open canal, partly covered canal, partly in tunnel, and, where it crosses the valleys, consists of large siphons 7½ to 11 feet in diameter. The total length of the structure is 254 miles, and in its completed condition it will supply Los Angeles with 250,000,000 gallons of water daily.

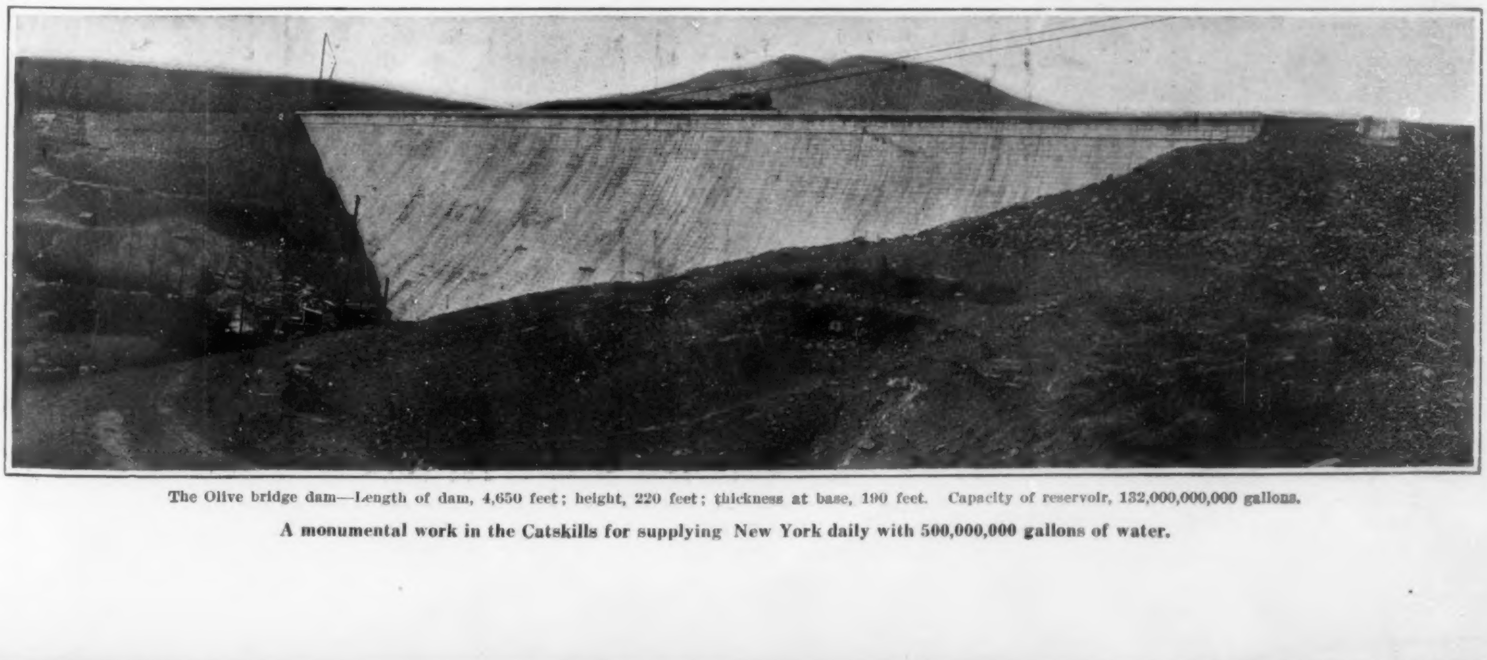
The greatest irrigation project in the world is that being carried out by the United States Government for the reclamation of desert lands lying between the Mississippi and the Pacific Coast. The great work consists mainly in the construction of dams, most of them of great size, for impounding the flood waters of the rivers and streams of the west and providing a vast system of irrigating canals for its distribution during the dry season. In some cases the dams are of limited height, but great length; in others they are short and of great height, as in the case of the Roosevelt and the Shoshone dams, which are over 300 feet in height, and the Boise Canyon dam, 350 feet high. These are the loftiest structures of the kind in the world. The canal system includes 341 miles carrying over 800 cubic feet per second, 375 miles carrying 300 to 800 cubic feet, and of 6,000 miles of smaller canals. When the project is fully completed over 3,000,000 acres of land, hitherto barren and desert, will be brought under cultivation.

In this connection, our thoughts turn naturally to that other great irrigation scheme rendered possible by the huge Aswan dam in Egypt. This world-renowned structure is built of solid masonry and extends for over a mile across the bed of the Nile. As recently enlarged by the addition of sixteen feet to its height and a proportionate increase of thickness, it provides a maximum head of water of eighty-six feet, and impounds the enormous quantity of 81,200,000,000 cubic feet of water. The dam is pierced by sluice-gates, by which the stored water is released for the use of the Egyptian agriculturalist as it is needed.

The great dam constructions for water supply are matched by those built for the development of hydro-electric energy—a field in which, because of limitations of space, we must be content to mention only the last and largest plant of all—the Keokuk dam across the Mississippi. This is a private commercial venture, built to furnish light and power in the Mississippi valley. The dam, 4,278 feet in length, reaches clear across the Mississippi; it is founded on good rock and has a bottom width of 42 feet and a height of 53 feet. The floods are controlled by gates, built in the dam. The power is developed in a vast power house, 132 feet wide and 1,718 feet long, which contains 30 hydro-electric units, each of 7,500 kilowatt capacity.

Long-span Bridges.

In tracing the development of bridge design and construction in this country and abroad, we find that, early in the period under review, American practice showed a broad divergence from that common in Europe. In the United States the typical American bridge, particularly the truss bridges used for railroad work, was designed with trusses of great depth and with long members of rather small cross sections, the result being to give to the American bridge an appearance of lightness and fragility, which, at least as far as its strength was concerned, was misleading. Probably a predisposing cause to this, and particularly to the universal adoption of the eye-bar for tension members, was to be found in the necessity for strict economy and in the universal desire of the American manufacturer to standardize work in the shop and in the field, and produce a type of bridge which would be easy of construction and erec-



The Olive bridge dam—Length of dam, 4,650 feet; height, 220 feet; thickness at base, 190 feet. Capacity of reservoir, 132,000,000,000 gallons.

A monumental work in the Catskills for supplying New York daily with 500,000,000 gallons of water.

Copyright by Irving Underhill

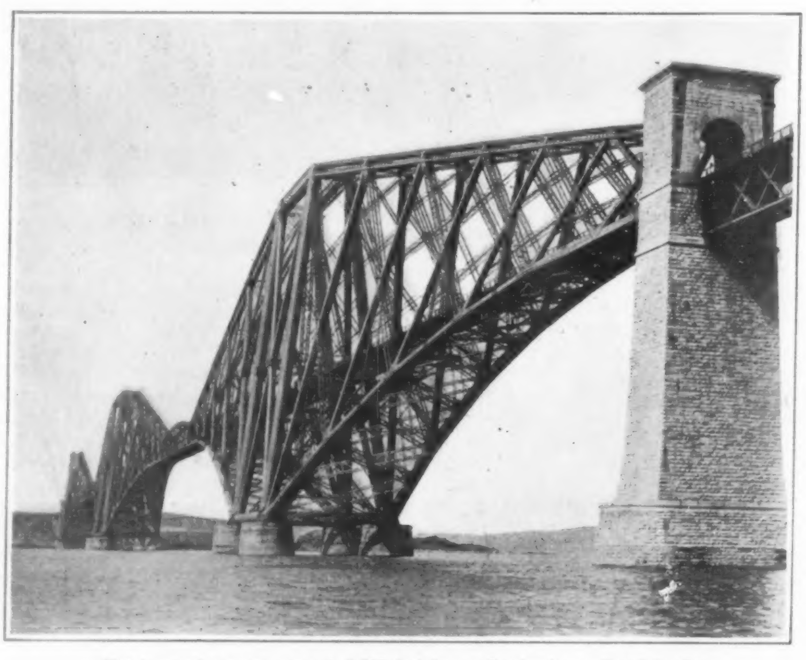
Main span, 1,470 feet. Shore spans, 725 feet. Width of floor, 120 feet. Capacity: Four electric railways; a 35-foot roadway, and two 10-foot footpaths.

The Manhattan suspension bridge across the East River, New York.

tion, and relatively to other types of bridges would be economical in cost. In Europe the bridge engineers favored riveted construction and a shallow depth of truss, and this involved an increase in the section of the various members and also a general increase in the weight of the bridge. The American eye-bar bridge had the advantage of cheap cost and quick construction and erection, while the European bridge, requiring more time, at least for erection, and costing more, had the advantage of greater stiffness and general rigidity.

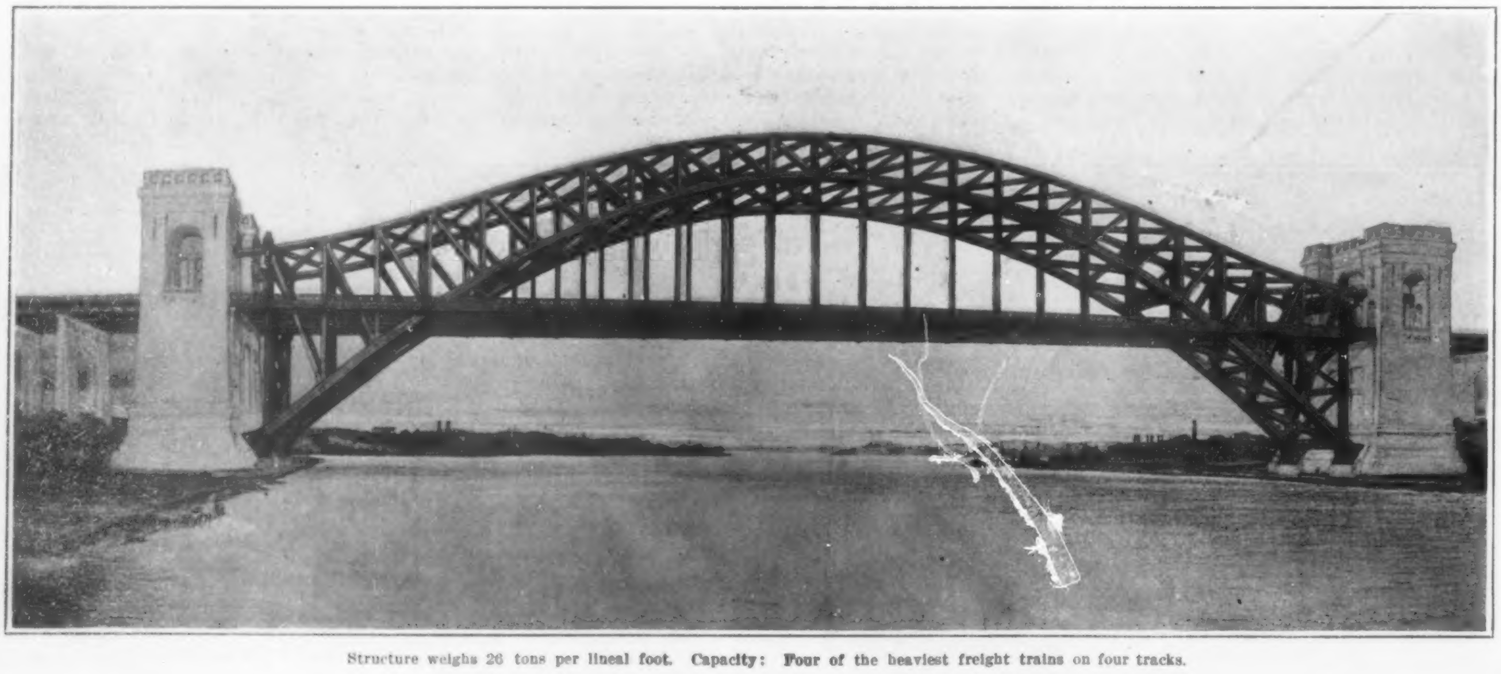
During the past fifteen or twenty years, the two schools of design have drawn together or overlapped; so that now the eye-bar is not unknown in later European designs, and the riveted bridge is becoming increasingly popular in America.

Seventy years ago that justly celebrated engineer, Robert Stephenson, presented plans for an entirely new type of bridge, each span of which consisted of a rectangular, plate-iron tube, the structure being designed to carry the tracks of the London and Northwestern Railway across the Menai Straits. The bridge was built double—that is to say there was a track within each tube, the spans consisting of four of 230 feet and four of 472 feet. This bridge produced as much astonishment and doubt as to its feasibility as the Brooklyn bridge or the Forth bridge did in later days; but it proved a great success and is in active service to-day. Of the same type was the Victoria bridge across the St. Lawrence River, a monumental structure, consisting of 25 spans, each 244 feet in length. It was removed about fifteen years ago to make way for a more modern structure. In 1855 Roebling built the Niagara suspension bridge with the then unprecedented span of 821 feet, and nineteen years later he commenced the construction across the East River, New York, of that truly beautiful and monumental bridge with which his name will be ever associated. The Brooklyn Bridge, as it is now called, is carried upon four 15-inch wire cables. It consists of two shore spans, each 900 feet in length and a main river span 1,595 feet between the towers. The work was completed and opened in 1883. In point of size and capacity there was



The two main spans are each 1,710 feet long. Carries two railroad tracks.

Forth bridge, Scotland; largest cantilever bridge in existence.



Structure weighs 26 tons per lineal foot. Capacity: Four of the heaviest freight trains on four tracks.

Hell-Gate bridge over the East River. Longest arch bridge yet built.

nothing to approach this structure at that time in all the world. The suspension bridge is a peculiarly American type, especially for long-span work. In 1895 the Williamsburg bridge over the East River was commenced, and after about seven years' work was opened. This structure was far more solid and had much greater capacity than the Brooklyn bridge, the full width of the floor system being 118 feet, as against the 80 feet of width of the earlier structure. This was followed by the Manhattan bridge with a main span of 1,470 feet, and a full width of 120 feet.

The great rival to the suspension bridge for long-span work has always been the cantilever, and of this type the most notable example is the great structure across the Firth of Forth, a few miles above Edinburgh, Scotland. This is a two-track railway bridge, and at the time it was built it was the wonder of the engineering world, and it is to-day and must forever be one of its most monumental structures. The two main spans measure 1,710 feet in the clear and its most interesting structural feature is the fact that the compression members are big tubes, generally of circular section, measuring from eight to twelve feet in diameter. The tension members are of lattice work. Benjamin Baker, its principal designer, said that he started out to build the stiffest and strongest large bridge in existence; and he succeeded in doing so; for the heavy express trains to and from North Scotland cross it at speeds of 60 miles an hour and over.

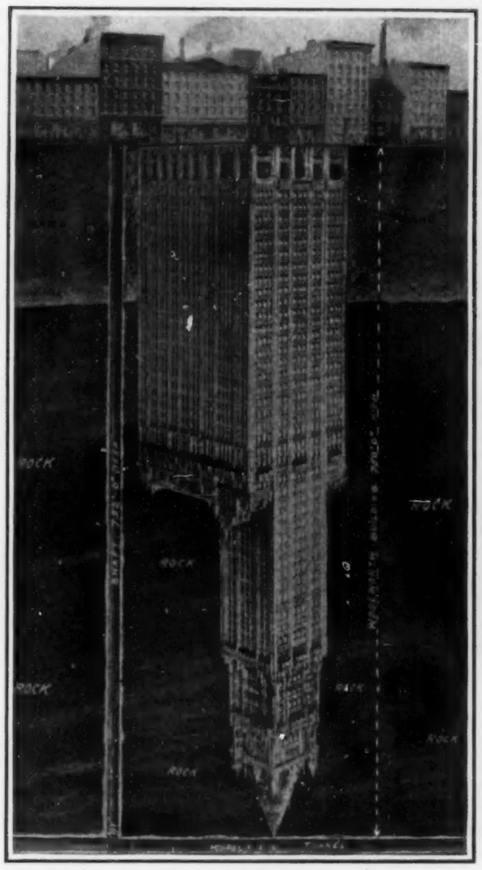
The new Quebec bridge across the St. Lawrence, which will replace the structure which collapsed a few years ago, consists of a main river span of 1,800 feet. This will be the longest cantilever span in existence. The bridge carries two railroad tracks, and it will weigh 18 tons per linear foot.

The longest single span arch bridge in the world is that which is now under construction across the East River at Hell Gate, which will provide four railroad tracks capable of carrying the heaviest freight trains in existence. It measures 1,017 feet between piers, and it rises 220 feet from the hinges to the crown of the chords. Its weight will be enormous, namely 26 tons per lineal foot of the bridge. The size of its members is shown by the dimensions of the lower chord, which is rectangular and about seven feet wide, and varies in depth from seven and one half feet at the crown to ten and a half feet at the abutments.

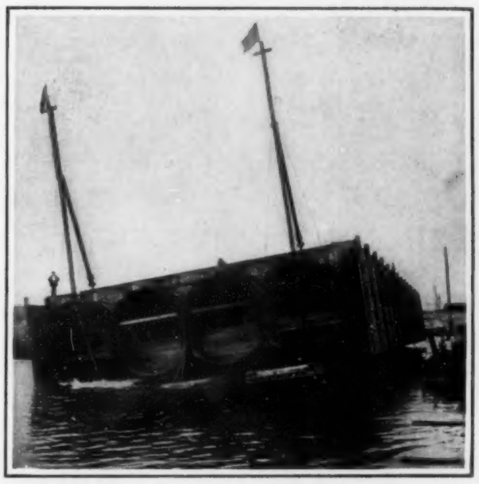
What the future will see in the way of the development of long-span bridges is suggested by the fact that plans are made and financial negotiations are under way for the construction across the North River of a double-deck combined freight-and-passenger suspension bridge, capable of carrying sixteen tracks, whose span between the main towers will be about 3,000 feet. The main towers of the bridge will rise over six hundred feet above the surface of the river.

Canals.

The construction of canals for inland water transportation dates from the earliest times. At the opening of the period under review, the Erie Canal connecting the Hudson River with Lake Erie may be taken as typical of such work both here and in Europe. It was opened in 1825, when it had a maximum depth of four feet, and its total length was 363 miles. Between 1836 and 1862 it was gradually improved, the depth being increased to seven feet; and at that time it had seventy-two locks. During the past decade further improvements have been undertaken with a view to increasing its capacity, and the work now under way and within measurable distance of completion will provide a



New York's highest building and deepest shaft. Where the aqueduct dips under the East River it sinks to a depth of 750 feet below the surface.



Launching section of Harlem River subway tubes. Flat boats being sunk to set the tube section afloat.

canal with a minimum depth of twelve feet, capable of taking barges of 1,000 tons. The canal leaves Lake Erie at an elevation of 565.6 feet above tide level, and reaches tide level on the Hudson River at Waterford. In the new canal the number of locks is reduced to 50, and the whole work of improvement at completion will have cost about $125,000,000.

The period under review has seen the completion of several great canals of the largest capacity designed for the use of ocean shipping. The first of these was the Suez Canal, which connects the Mediterranean with the Red Sea. It was built by De Lesseps and completed in 1869. Originally it had a bottom width of 120 feet, 250 feet width at the surface and was 28 feet deep. In 1897 work was begun on the enlargement and deepening of the canal to a minimum depth of 31 feet. It has been improved, not only by increasing its width, but by the construction of several large and commodious sidings to facilitate the passing of vessels.

The Kiel Canal, stretching from the mouth of the Elbe to the Baltic, a distance of sixty miles, was begun in 1887 and completed in 1895, with a bottom width of seventy feet and a top width of 220 feet, and a depth of 29½ feet. This year the work of reconstruction and enlargement was completed, and to-day the canal has a top width of 335 feet, a bottom width of 144 feet and a minimum depth of 36 feet. The locks, 1,082.6 feet long by 147.6 feet wide, are the largest in existence. The canal is proving its vast military importance during the present war.

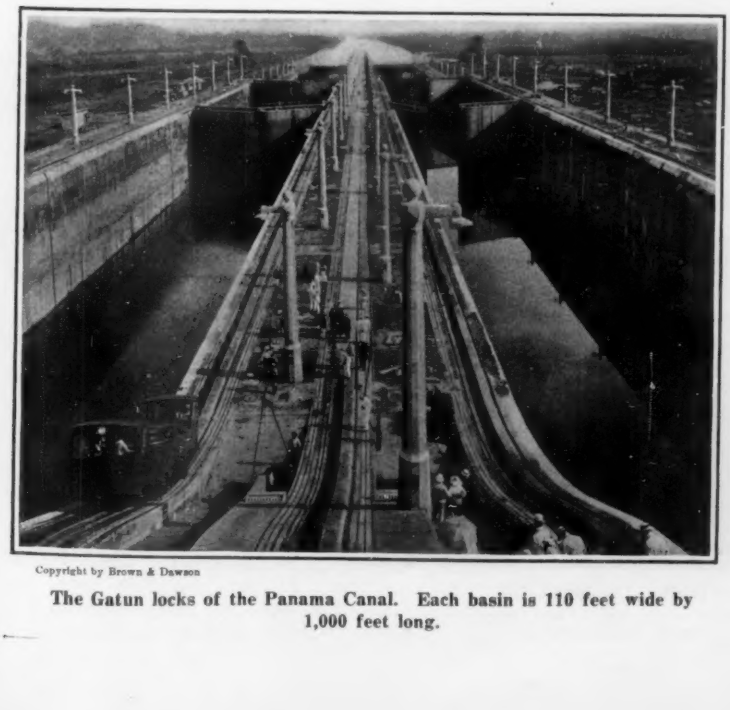
The greatest of all works of this kind, however, so great indeed, as to be in a class by itself, is the Panama Canal, which was commenced in the early eighties by De Lesseps, and after many years of fruitless endeavor, was finally purchased by the United States Government, and has recently been completed by the United States engineer corps. The Panama Canal is remarkable not so much for its length, which is fifty miles from deep water to deep water on the Pacific, as it is for its great width and depth, and for the enormous amount of excavation involved and the great difficulties encountered because of the climate and because of the unstable nature of the ground through which it is cut. Our American engineers solved the problem of the turbulent Chagres River by building the great dam at Gatun, with its surface level eighty-five feet above the sea and a surface area of 165 square miles. The lake extends from Gatun, some eight miles from the Atlantic, to the farther end of the Culebra cut, a total distance by the channel of 32 miles. The dam is over 2,000 feet wide at its widest point, and its crest is 115 feet above sea level. The depth of the canal throughout is 45 feet. Its minimum width at the bottom is 300 feet, and its maximum width 1,000 feet, where the channel passes through Gatun Lake.

The locks have a usable length of 1,000 feet and a width of 110 feet. The total amount of excavation long ago passed the 200,000,000 cubic yard mark, and it is continually increasing. The canal is finished except for the removal of the slides, which will probably continue to come down into the canal prism until the unstable material in the Culebra cut has reached its natural angle of repose. It is possible that the final total of excavation when this point is reached will be between 230,000,000 and 240,000,000 cubic yards. The total cost of the canal will be about $400,000,000.

Sub-aqueous Tunnels and Subways.

Over the portals of the main towers of one of the early suspension bridges, that over the Avon at Clifton,

(*Concluded on page 533.*)



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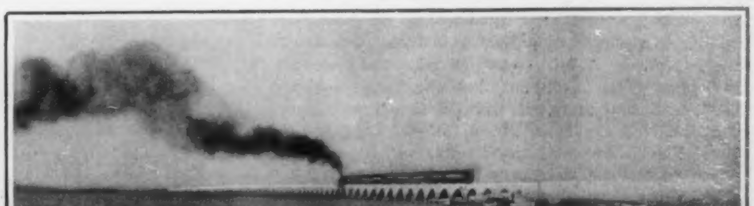
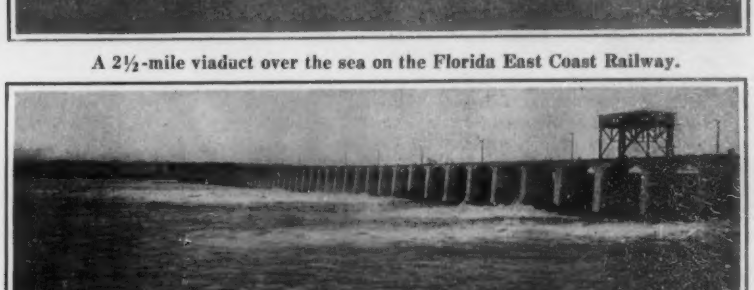
The Gatun locks of the Panama Canal. Each basin is 110 feet wide by 1,000 feet long.

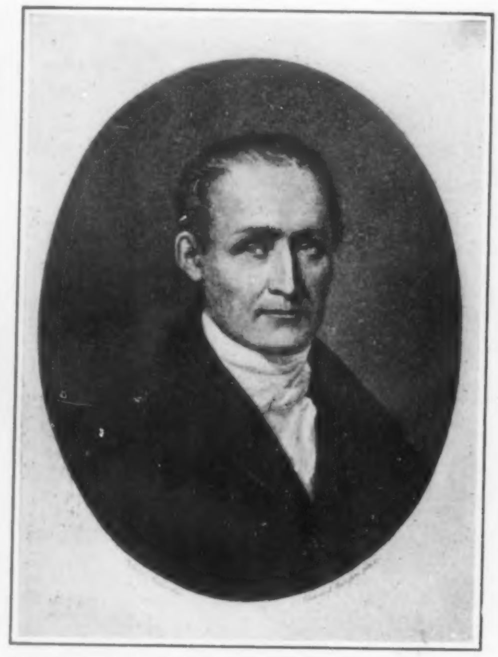


A 2½-mile viaduct over the sea on the Florida East Coast Railway.



Keokuk dam across the Mississippi River for generating 300,000 horse-power. Height, 52 feet. Length, 4,850 feet.

Louis Daguerre, from a daguerreotype.



Joseph Nicéphore Niepce, inventor of photography.

Fox Talbot, the father of modern photography.

The Invention and Development of Photography

From the Daguerreotype to the Moving Picture

THE father of photography was Joseph Nicéphore de Niepce, whose process appeared in 1824. In the Niepce process, a silver-faced copper plate was coated with asphalt dissolved in oil of lavender and dried. It was then exposed to light in the camera, or in the case of an engraving, by superposition. Thereupon it was washed over with a combination of one part of oil of lavender and ten parts of petroleum. The picture was then washed in water and dried. Next the plate was placed in an iodine fuming box until the bright silver ground turned dark. On removing the part of the asphalt remaining, the lights and shadows of the picture appeared in their proper relation, or instead, the plate was etched and inked and printed as in ordinary etching.

Next came L. J. M. Daguerre, who published his process in 1839. A copper plate, one surface of which had been silvered and highly polished, was fumed with iodine, then exposed in the camera and developed with vapor of mercury, and fixed in a solution of hyposulphite of soda. The solvent action of hyposulphite of soda on the silver haloids was discovered by Sir John Herschel. This is briefly the process as published by Daguerre in 1839. The exposure required in the camera was about fifteen minutes. Niepce and Daguerre had formed a partnership to prosecute their researches together, so that some of the credit of having invented the daguerreotype process belongs to Niepce.

Soon after this, however, by the addition of bromine to the iodine by Goddard (1840) and chlorine by Claudet (1841) the plates were made very sensitive. We find Dr. Draper in New York in the year 1840 making daguerreotype portraits in from twenty to ninety seconds. M. Fizeau discovered that by treating the daguerreotype with double hyposulphite of soda and gold it was made more permanent and very much more beautiful.

Fox Talbot and the Calotype Process.

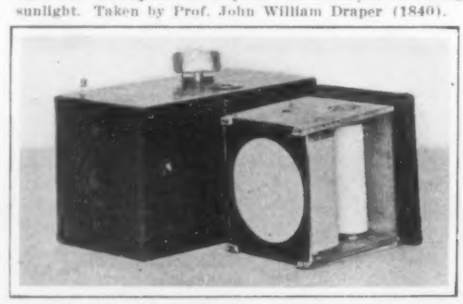
Next came the Calotype or Talbotype, the invention of Mr. Henry Fox Talbot. This may be regarded as one of the most important inventions in photography, for it introduced the photographic negative from which an unlimited number of prints may be made. Talbot's process was published in 1840. A solution of nitrate of silver was prepared, brushed over a sheet of paper, and dried. Then the paper was dipped in a solution of iodide of potassium, washed in water, passed between blotting paper, and dried. This was called iodized paper.

When the paper was required for use, it was washed with a solution of nitrate of silver fifty grains, water one ounce, acetic acid one sixth of an ounce. This was called "Solution A."

"Solution B" was a saturated solution of gallic acid in cold water. The two solutions were mixed in equal parts, just before using. Talbot called this "gallo-nitrate of silver."

The first photograph of a human face.

A portrait of Miss Dorothy Catherine Draper, taken in America. It required an exposure of 6 minutes in strong sunlight. Taken by Prof. John William Draper (1840).



The first kodak (1888), showing roll-holder and roll film for 100 exposures.

Loading, unloading and developing were done at the factory.

The first moving pictures ever exhibited in public.

They were made by Henry Heyl and were projected on a screen before 1,600 people in Philadelphia in 1870.

The iodized paper was treated with this solution and again dried. The paper was then exposed in the camera and developed with the gallo-nitrate of silver and fixed in hyposulphite of soda. Talbot found later that, by waxing, the paper negative was rendered more translucent, so that it gave better results in printing.

Wet-collodion Negative and Albumen Silver Print.

The use of collodion as a vehicle to hold the silver haloids upon plates originated with Frederick Scott Archer in 1850.

Pyroxyline is dissolved in a mixture of ether and alcohol; soluble iodides and bromides are added to this. The mixture is flowed over a glass plate and allowed to set, and then immersed in a bath of silver nitrate. This plate after exposure in the camera is developed with acidified ferrous sulphate or pyrogallic acid.

This process was used almost exclusively for making both negatives and positives on glass for many years, but its use is now very limited except in the photo-mechanical processes.

Blanquard-Everard introduced albumen paper into photography in 1848, after Claude Nicéphore Niepce de St. Victor had shown that good negatives could be made by the use of albumenized potassium iodide, sensitized with silver nitrate on glass. Gray invented the collodion process in 1850, which only one year later was brought to perfection by Fry and Scott Archer. Lemercier, Barreswill, and Davanne invented photo-lithography in 1852. After Henry Fox Talbot introduced the chrome gelatine process, it was but a step for Paul Pretsch to obtain the printing plates by electrotyping swelled gelatine negative (1845), and thus to invent heliography. Talbot's work also inspired the French engineer Alphonse Louis Poitevin to use the chromate gelatine process for devising the modern carbon process in 1855.

Printing-out Papers.

Printing-out papers are made by coating paper (usually enameled) with an emulsion compound of gelatine, chloride of silver, with more or less free nitrate of silver. Most of them are faced with collodion. The process was first worked out successfully by George Wheaton Simpson in 1861 with collodion, and by Abney in 1881 with gelatine. The newer developing papers, one of the most successful of which is the invention of Dr. Leo H. Baekeland, have all but superseded the printing-out papers.

The Evolution of the Carbon Process.

Carbon printing, in the form now in use, is the result of the action of many minds, and the honor of its discovery cannot be ascribed to the ingenuity of any one person. It may be traced back as follows: Mungo Ponton in the year 1839 discovered that white paper treated with a

(Concluded on page 560.)

Charles Wheatstone, a great English physicist, who was a pioneer worker in telegraphy.

Communicating Over Great Distances

The Invention of the Telegraph, Telephone and Wireless Telegraphy

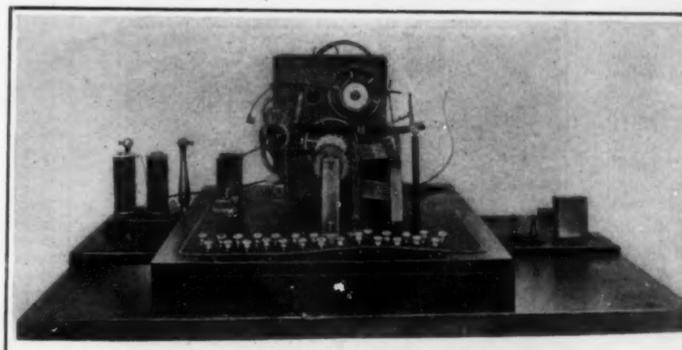
A Record of Achievement from Morse to Marconi

Sir William Thomson (later Lord Kelvin) inventor of the siphon recorder.

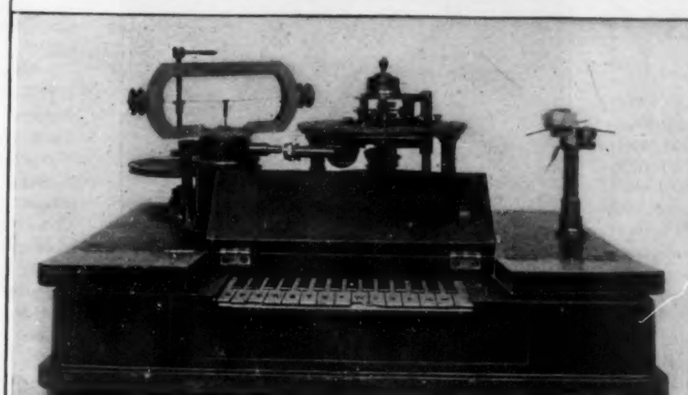
THE SCIENTIFIC AMERICAN came into existence with the dawn of telegraphy. The pioneer discoveries in electro-magnetism had been made by Oersted, Ampère, Arago, Barlow, Sturgeon, Faraday, and Henry. Without them Morse could not have created the telegraph, as we Americans know it. The same may be said of Wheatstone in England, and of pioneers in other countries. Europeans are not willing to concede to Morse the credit of having invented the telegraph, and Americans are not willing to concede to Europeans the credit of having anticipated Morse. As a matter of fact, the invention of the telegraph, like most great inventions, does not belong to any one man or any one country. It grew with scientific knowledge. To Morse undoubtedly does belong the credit of developing the commercial side of the telegraph, as we know it. He, in conjunction with Vail, worked it out on a practical scale, perfected details, invented the Morse alphabet, and last, but not least, succeeded after a great amount of trouble and many disappointments in obtaining the support of Congress toward making it a national enterprise.

After the instruments had been brought to something like commercial perfection, the next important advance was multiple transmission. In 1853 Gintl of Vienna and Frischen and Siemens and Halske independently experimented with apparatus intended to transmit simultaneously from both ends of the same line. While the solutions proposed by these inventors were mechanically sufficient for the purpose, they overlooked an important factor which had not before been considered important in land telegraphs—the electro-static capacity of the line. This difficulty was first successfully overcome by Stearns of Boston in 1871, at a time when duplex working was fairly common. The chief workers in this field were Gintl, Frischen, Siemens and Halske, Preece, Farmer, Nystrom, Maron, Winter, Stearns, and Muirhead.

The problem of how to send two messages in the same direction being solved, the transmission of four messages simultaneously over the same line was attacked. This seems to have been first proposed by Stark of Vienna in 1855, and subsequently worked at by Bosscha, Kramer, Mason, Schaak, and others. But the first to obtain satisfactory results was Edison, who invented his method in 1874. The principle embodied in the quadruplex is that of working over the line from each end with two currents, that differ from each other in strength or nature, so that they will affect only instruments adapted to respond to just such currents and no others; and by so arranging the receiving apparatus as not to be affected by the currents transmitted from its own end of the line. Thus by combining instruments that respond only to variations in the strength of currents from the distant station with instruments that respond only to the change in the direction of current from the distant station, and by grouping a pair of these at each end of the line, the quadruplex is the result. Four sending and four receiving operators are kept busy

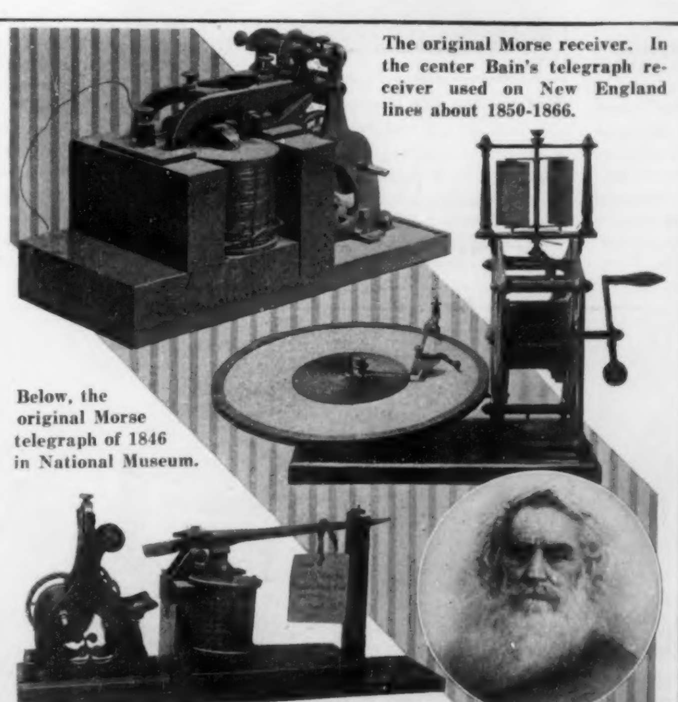


Grandfather of the stock ticker. Original Hughes printing telegraph.



Photographs by C. H. Claudy

The original printing telegraph of R. E. House.



The original Morse receiver. In the center Bain's telegraph receiver used on New England lines about 1850-1866.

Below, the original Morse telegraph of 1846 in National Museum.

Samuel F. B. Morse, his telegraph and that of Bain.

at each end, or eight in all. Aside from other material advantages it is estimated that at least from \$15,000,000 to \$20,000,000 has been saved by the Edison quadruplex, merely in the cost of line construction in America.

Another system of multiple transmission was proposed by Moses G. Farmer of Salem, Mass., in 1852, in which by a commutating arrangement the main line was put in rapid succession in contact with a series of branch wires by proper connection at the sending station and two communicators worked in unison. It was then proposed to divide the transmitting capacity of the main line wire among a number of branch wires, so that the messages might go over all of these at the same time. A similar arrangement was proposed by Meyer and shown in operation at the Vienna exhibition in 1873. The same principle is adopted in Delaney's telegraph.

Although the mere extension of telegraphs from land to submarine lines can hardly be called invention, yet very many new problems presented themselves for solution in this extension. The application of Stearns' duplex method to submarine telegraphs involved peculiar difficulties on account of the very large capacity of the line, and in the more important cables, the length of the circuit. The credit of having completely overcome these difficulties for submarine cables is mainly due to Dr. Muirhead of London. The electro-static capacity of the line is such that signals could not be so instantaneously transmitted as they were on land lines. Moreover, there was no opportunity of using relays so as to shorten the longer lines. Then there were the evident mechanical difficulties of manufacturing and of submerging a cable in deep water. The experiments in short lengths in the English Channel and elsewhere had proved successful and had aroused the interest of American and English business men in a transatlantic cable. It is due to the persistence of Cyrus W. Field that we owe the laying of the first transatlantic cable in 1866. The Anglo-American Telegraph Company was organized to undertake the task. With the aid of the "Great Eastern" a submarine cable was laid between Valencia, Ireland, and Trinity Bay, Newfoundland, between July 7th and August 4th. It is needless to recount the early success, the cessation of intercourse due to accidents and the final resumption of communication. They are now matters of common knowledge.

The laying of long cables brought out the fact that existing telegraphic apparatus was not sensitive enough for rapid signaling. Thomson, later Lord Kelvin, overcame the difficulty by inventing the mirror galvanoscopic receiver, which invention he followed later by his siphon recorder, probably the most sensitive recording telegraph known. Improvement in methods of working cables soon followed, among which in the early days, probably the most notable, is the introduction of condensers between the ends of the cable and the earth.

A few years ago, John Gott of Hove,

Bell's original Centennial iron box receiver.

Alexander Graham Bell.

Emile Berliner.

The first instrument made and used by Bell.

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Sussex, England, invented a new method by which Morse signals can be sent through long submarine cables with some approach to the facility enjoyed in the transmission of the familiar dots and dashes on overland circuits. The method obviates retransmission at the cable or land ends, and eliminates the siphon recorder, substituting for it an ordinary Morse recorder or sounder.

Successful long distance cable working has involved the use of a reversing key, to send two element signals by changing the direction of the current. In Gott's method the change in direction of the current is effected after each signal by the use of a polarized relay through which the cable is discharged, and the path of the current reversed for the next sending signal. With this system it is possible for an operator at San Francisco to communicate directly with London. While the method does not phenomenally increase the actual speed of transmission, it makes submarine telegraphy more accurate, effective and uniform.

High Speed and Printing Telegraphs.

From the dawn of electric telegraphy inventors have been at work filling the patent records with printing telegraph schemes, some brilliant, some stupid and nearly all useless. Out of several hundreds of printing telegraphs invented prior to the beginning of the twentieth century, only the Hughes and Baudot and the stock tickers achieved any real success. With the stock tickers the problem to be solved was comparatively easy. They were required to work only over distances of a few miles. High speed was desirable, but not absolutely necessary. One man by playing on a keyboard could transmit messages to a considerable number of subscribers, and there was no necessity to deliver the messages, no need to count the number of words in each message, to sign and time the messages or cut up the tape and paste it on telegraph blanks, no need to keep copies of the messages for record, or put them in envelopes or address the envelopes and send them out by messenger. The conditions were of the simplest character, and the consequence has been that the stock tickers long ago reached their full development. One of the earliest of these stock tickers was that of Dr. S. S. Laws, who patented at the end of 1866 his gold reporting telegraph. E. A. Callahan, an ingenious printing telegraph operator, saw that there were unexhausted possibilities in the idea, and his foresight and inventiveness made him the father of the ticker, in connection with which he was thus, like Laws, one of the first to grasp and exploit the underlying principle of the central station as a universal source of supply. Callahan transformed his indicator into a ticker that would make a printed record. At this juncture Edison entered the field. In collaboration with Pope, he invented a one-wire printer. Financed by Gen. Lefferts he started to improve the stock ticker. The well-known universal ticker in widespread use in its day was one result. Since then the stock ticker has enjoyed the devotion of many brilliant inventors—G. M. Phelps, H. Van Hoevenbergh, A. H. Knudson, G. B. Scott, S. D. Field, and John Burry—and remains in extensive use as an appliance for which no substitute or competitor has been found. It is significant of Edison's work, now dimmed and overlaid by later advances, that at the very outset he recognized the vital importance of interchangeability in the construction of this delicate and sensitive apparatus.

"The only successful page printing telegraphs in very extensive use to-day in Europe are still nothing but glorified stock tickers, in the terms of Mr. Donald Murray, himself a distinguished inventor in this field. In a paper which he published some years ago he summarized the whole situation excellently as follows:

"The Hughes instrument prints on a tape, and the speed is limited by the manual dexterity of the operator and the keyboard. The gain compared with the Morse key is small. The Baudot printing telegraph, which is largely used in France, and which connects Paris with nearly all the European capitals, may be described as a multiplied Hughes, as it is equivalent to four and even six Hughes instruments working over a single wire. It is exceedingly ingenious, highly practical, and gives admirable service within its limitations; but it is not a fully developed prnting telegraph system because it is not provided with a typewriter keyboard for transmitting, and it does not print the messages in page form. It prints on a tape, and it does not save labor to an appreciable extent, compared with the Morse key. Its great virtue is that it saves wires. In fact, in France and some neighboring countries it may be said to have met the want that has been supplied in Anglo-Saxon countries by the Morse quadruplex. The Morse quadruplex and the Baudot might be described as the second stage in the development of the modern telegraph. The third and final stage of completely developed machine telegraphy has only been reached after 1900. Within this brief period there has arisen the Pollack-Virag, Buckingham, Rowland, Murray, Morkrum, and Siemens and Halske high-speed telegraph systems. Telegraph companies and governments have never been kindly disposed toward machine telegraphy."

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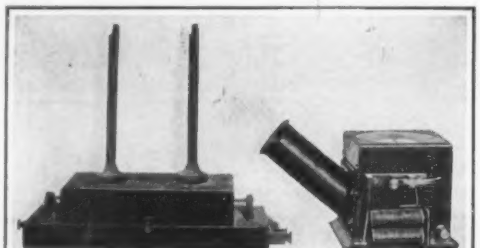
Prof. Michael I. Pupin, inventor of the load coil that made transcontinental telephoning possible.



Model of the Reis telephone in the National Museum of Washington.

Alexander Graham Bell and the Telephone.

The invention of the telephone constitutes one of the greatest advances that have been made in the art of communicating over great distances. It is well known that sound is transmitted through the air from speaker to hearer by means of waves, condensation and rarefaction, which affect the drum of the ear. As early as 1831 Wheatstone showed that these waves could be transmitted from one place to another at a moderate distance through wooden rods and afterward conveyed to the air by the vibrations given to the air by the end of the rod. Similarly, vibrations given to one diaphragm to produce the corresponding vibrations in another diaphragm at a distance by means of electric currents was the problem of the electric telephone. The first to propose this appears to have been Charles Bourseul, who in 1854 suggested the use of two plates, one at the transmitting station, which, by the varying pressure of the air due to the sound waves, would open and close an electric circuit while the other was to be acted on at the receiving station by an electro-magnet through which the electric currents passed.

In 1861 Philip Reis of Friedrichsdorf disclosed in a lecture an instrument which he called a telephone, for the production at a distance of music and human speech. The apparatus consisted of a flexible membrane forming one side of a box, with which by means of a mouthpiece the sounds could be directed. This instrument was made to open and close an electric circuit at each vibration. At the receiving end, an electro-magnet consisting of a thin rod of iron surrounded by a coil was placed. The successive interruptions and closings of the electric circuits took place in accordance with a discovery made by Dr. Page of Salem, Mass., in 1837.

There is no good reason to suppose that Reis's telephone ever talked, although it probably did transmit musical sounds. His method could not be successful for speaking simply because speech has more characteristics than pitch. To reproduce not only corresponding vibrations, but also loudness and quality of the sounds, a transmitter and receiver were required which did not depend for their action on such interruptions of the current, but which varied the current in a pulsatory manner similar to the variations of pressure on the diaphragm due to the waves.

It was not until Alexander Graham Bell produced his apparatus in 1876 that these requirements were met. That he thoroughly understood his problem is abundantly clear from the patents and records of his early experiments. Without re-

(Concluded on page 366.)

Marconi and one of his early wireless sets.

The Patent Office and Invention Since 1845

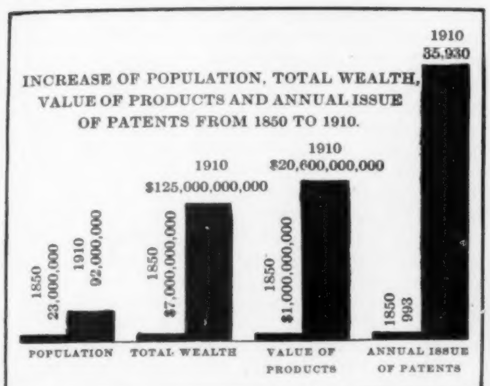
How the Government Has Kept Pace With the Inventor

By William I. Wyman

IN 1845, the birth year of the SCIENTIFIC AMERICAN, the present patent system was nine years old. In 1836 the Patent Office was placed on a distinct basis, the system reorganized and the examination or American method of searching patents inaugurated.

Thomas Jefferson Was the First Commissioner of Patents.

The American patent system was founded under the act of 1790. Under this act the Secretary of State, the Secretary of War and the Attorney General constituted a board to consider all applications for patents. Thomas Jefferson, the first Secretary of State, was in effect the first Commissioner of Patents and the first Examiner. It is said that he personally examined into and determined the patentability of every application filed during his first years in office as head of the State Department. The grant of a patent then was not only a procedure of exceeding dignity, being signed by the President, the Secretary of State and the Attorney General, but was issued with some reluctance. Only three patents were permitted to see the light of day in 1790.



From this modest beginning, the business of the patent system grew slowly, but steadily. From 1790 to 1802 it required but one State Department clerk to perform all the clerical work pertaining to the Patent Office, the entire records of which were contained in a dozen pigeonholes. Up to 1836, about 10,000 patents were granted. In that year, the Patent Office became an independent bureau, headed by a commissioner, assisted by *one* examiner and six other subordinate clerks and employees. While the reorganization gave the Office a dignity and standing it did not have before, still the force provided to cope with the pressing demands of inventors does not now appear to be excessively large. And yet critics, whose sense of economy was more acute than were their gifts of imagination, decried the sheer waste entailed by an organization so extravagant in men. But applications came pouring in, and in the following year the examining corps had to be doubled by the appointment of an additional examiner, and in 1839 the position of two assistant examiners was created to keep pace with the growing business.

	Patents, Total Issued to that year	Total Wealth	Per Capita	Population	Value of Products
1850.	7,000	7 Billion	$308	23 Million	1 Billion
1860.	27,000	16 "	514	31.4 "	1.885 "
1870.	98,000	27* "	750*	38.5 "	3.400 "
1880.	223,000	43 "	870	50 "	5.3 "
1890.	419,000	65 "	1,036	62.6 "	9.4 "
1900.	640,000	88½ "	1,165	76 "	13 "
1910.	945,000	125* "	1,400*	92 "	20.6 "

* Estimated.

The act of 1793 was the only one which provided for the grant of a patent without examination. In 1836 the modern examination system was instituted, by which a search through patents and publications was made to determine the question of novelty. This act also for the first time made a positive requirement for the inclusion of a claim in the specification in the following terms:

"He [the inventor] shall positively specify and point out the part, improvement or combination which he claims as his own invention or discovery."

The Early Days of the Present Patent Office.

In 1836 the erection of the Patent Office was begun; the building was finished in 1840. This original structure forms the F Street wing of the present building. In 1845 the patent system was well on its way and the Office properly housed, with an official force of one commissioner, two examiners, and two assistant examiners. In that year, 1,246 new applications were filed, besides many caveats, and the work was becoming too heavy for this limited force to handle effectively. This condition became and continues to be chronic.

Even as early as 1850, only five years after the founding of the SCIENTIFIC AMERICAN and but fourteen years after the reorganization of the Patent Office, American inventions were numbered among the most notable produced. In 1857, this country issued over one third more patents than Great Britain, which at that time had a substantially greater population. In that year, the United States with a population of 23,000,000 issued 2,910 patents, Prussia with almost 17,000,000 issued 48, while Russia, with 70,000,000 population, issued 24 patents. Commissioner Holt, in his annual report for that year, in reviewing the statistics, grows eloquent and philosophizes thus:

"As the light of liberty waxes dimmer, so does the inventive genius flag and dull apace, until finally, amid the darkness of the political night which broods over Eastern lands, it is utterly extinguished."

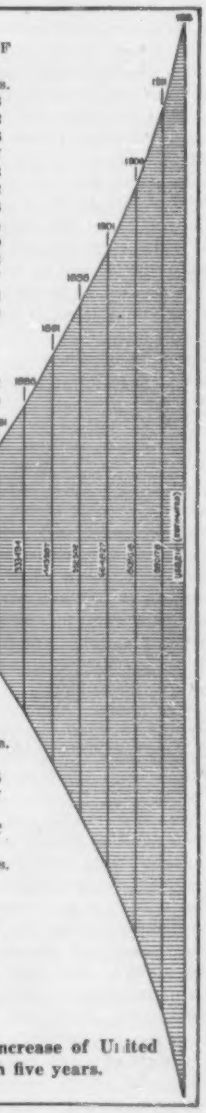
The Ante-Bellum Period of American Invention.

During this decade, the one immediately preceding the civil war, the stimulating influence of invention upon industry became noticeably apparent. Southern New England was tending to become a gigantic workshop and the character of entire sections of New York and Pennsylvania and Ohio radically changed from agricultural to industrial communities. The invention of the sewing machine—the greatest labor-saving device of the ages—was of itself a tremendous stimulus, and the opening up of the West through the railroad meant activity in iron production and the basic engineering industries. The reaper and the thresher made the opening up of the West profitable and the inventions in firearms, machine tools, locks and labor-saving devices and textile machinery initiated new industries and accelerated the growth of the country by leaps and bounds. By the time the civil war broke upon the country, only a quarter of a century after the inauguration of the present patent system, and in spite of the pre-eminently agricultural character of her pursuits, this country gave every evidence that she was to be among the first of the industrial nations.

After the Civil War.

The distracting period of the civil war over, activity in enterprise increased energetically, and in the year after the civil war closed there were filed in the office over three times as many applications as were filed in 1861. During the war, the Bessemer process was developing, and the influence of this most stimulating of inventions, which inaugurated the age of steel and our present intensive industrial era, became felt not long after its close. Then began a period of true national expansion—the further developing of the West, with strenuous enterprise in reaching out with new railroads, building of steel mills and locomotive works—marking an inflation of energy, industry and finance, which culminated in the severe panic of 1873. The country paused for a little while and took account of stock at the great Centennial Exposition in 1876. The wonders of our material advance, practically all of which were induced by invention, such as the Corliss engine, the textile machines, woodworking tools, machine tools, the sewing machine, hydraulic machinery and various kinds of automatic appliances, were there spread out for inspection to demonstrate the ingenuity of the American inventor and the intimate relation existing between him and what was making American development.

The period from 1865 to 1880 gave inkling of the dawn of a radically new era. The electrical age was prognosticated in the dynamos of Gramme, Siemens and Brush, the Bell telephone and the arc lamp. But they left no impress upon industry or the social life of the time until the next period got into swing. From 1867 to 1879, the annual number of applications filed remained stationary and averaged around 20,000 per year, but about the time specie payments were resumed, the country appeared to take on a new lease of life.



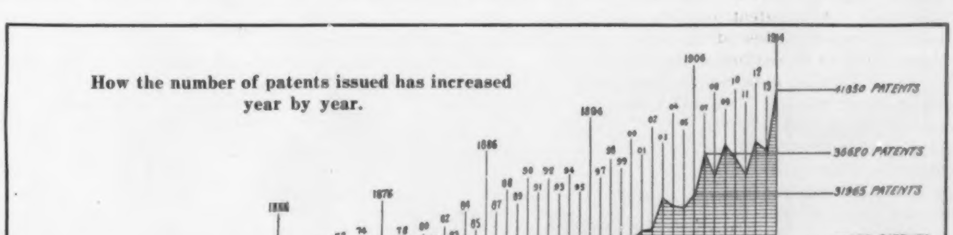
THE MOST FERTILE FIELDS OF INVENTION.

	Patents.
Carriages and Wagons	37,728
Clasps, Buckles, Buttons	18,772
Harvesters	15,006
Plows	15,907
Mills	18,803
Machine Elements	15,062
Builders' Hardware	15,826
Games and Toys	12,164
Locks and Latches	11,930
Mills, Grinding, etc.	18,803
Railways	11,347
Railway Rolling Stock	15,462
Seeders and Planters	11,059
Water Distribution—Mains and Pipes, Cocks and Faucets, Pipe Couplings, etc.	21,592
Wood Working	10,060
Washing Machines and Other Laundry Appliances	11.385
Steam Engines	11.907

SOME OF THE MOST PROLIFIC INVENTORS.

	Patents.
Edison	977
Elihu Thomson	617
Francis H. Richards	847
Edward Weston	299
Charles E. Scribner	437
George Westinghouse	340

Diagram showing ratio of increase of United States patents for each five years.



How the number of patents issued has increased year by year.

In 1867, 21,276 applications were filed, and in 1879, 20,059; in the next year (1880) the number increased to 23,012, and in 1889 reached 40,575, more than double the number filed ten years before. In that decade the country literally jumped forward and inventive ingenuity reached the golden age of its activity. For more exhaustive treatment of this decade the reader is referred to the editorial page of this issue.

The present commissioner, Hon. Thomas Ewing, in his endeavor to conserve the vast benefits the Patent Office has conferred upon the American people, has instituted several reforms to overcome some of the abuses which have gradually crept into the practice and grown by degrees to menacing proportions. Among these is the tendency to initiate unnecessary interferences. They are now being reduced in number wherever it is possible without injury to anyone's rights, and thus avoid litigious proceedings and lessen the financial burden upon the inventor. They are a source of delay and expense to the applicants and constitute an involved and burdensome handicap which has sometimes been laid heavily upon the shoulders of a meritorious inventor.

Another innovation concerns the rights of the public at large and relates to an abuse of privilege on the part of those inventors who desire to delay the issue of their patents to prolong their life. In court practice, no matter how important the stake, an issue is soon reached upon which the case may go to trial. But until the famous decision in *ex parte* Miller and the issuance of the orders by the present commissioner, by which every dilatory prosecuted case is made special and is treated by him personally, through his supervisory authority, such coming to an issue could be delayed indefinitely. This, the greatest of all abuses of privileges on the part of applicants, is in a fair way to be effectively remedied.

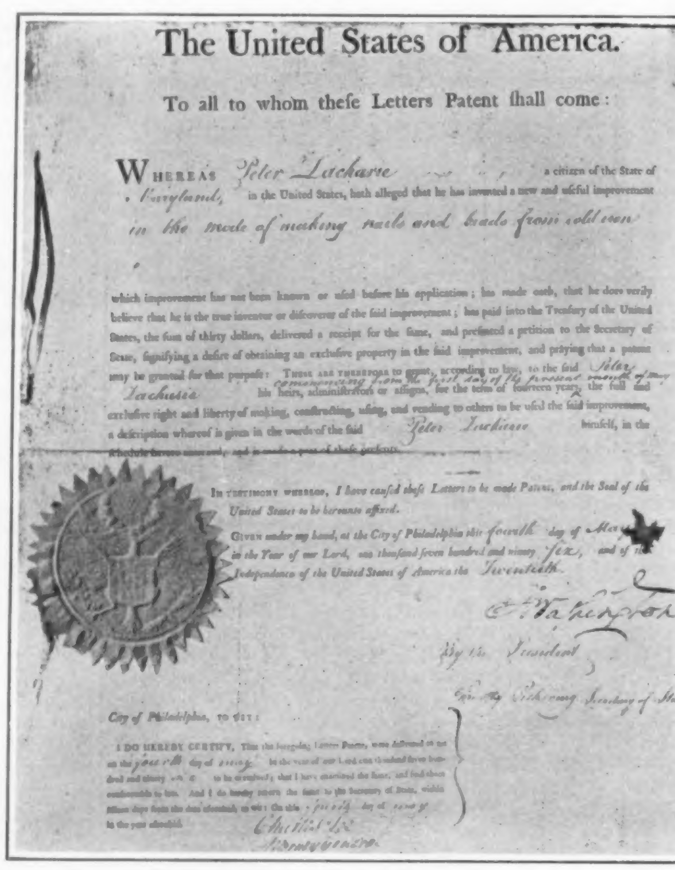
The Advent of the Hired Inventor.

The larger concerns have in connection with their patent departments or in association with them research laboratories with a corps of highly trained engineers and technical and scientific assistants. Every improvement of a patentable nature, if of proved utility or possible merit, becomes the subject matter of an application, not only for the monopoly that a patent may bring, but also as a protection in its manufacture and as a matter of record. The patent department advises the technicians whether a proposed device may be patented, or whether it infringes an existing patent, and also appraises the validity and value of patents offered to the company for sale. The experimental department will try out new ideas or develop them to some conclusion. Many of the big things now come through these organizations, for frequently in the evolution of an art, an instrumentality may be so complex, require the expenditure of so much skill and money to develop and demonstrate, that only a company with large resources is able to handle the proposition. Thus, the General Electric Company took several years, plus an expenditure of a few million dollars, to develop the Curtis turbine. It is by no means uncommon for a promoter to spend over $100,000 to develop a process or apparatus so it will be marketable. Edison, who, if not incorporated, is a host in himself, frequently spent thousands upon thousands in investigations and has made experiments by the hundreds before he was in a position to announce results. There are some devices which are so intricate in design, notably type setting and casting machines, that anywhere from a quarter to one million dollars may be expended in construction and improvement, in trials and changes, only to prove eventually, what could not possibly be determined in advance, that it could not meet the various requirements demanded in commercial practice. Mark Twain sank his personal fortune of several hundred thousands in a typesetting device, probably the most intricate bit of mechanism ever devised, because, while the machine did everything it was designed to do, it was too intricate to be understood by the ordinary mechanic.

Then again, the device may be simple enough, its merits sufficiently obvious, but it may require more business acumen, push and advertising to introduce it than would be required to market an article of staple and competitive character, or sometimes, no character at all. A well-known instance of this inertia on the part of the public is the case of a certain safety razor, which required prodigious efforts on the part of its promoters to eventually get the public to use what appeared to be a self-evident filling of a long-felt want. No inventor can afford to create without the protection of the patent laws, because the labor and expense he is placed under preliminary to establishing the utility of his invention becomes a fixed charge and the very means to handicap him against a piratical competitor, who can start without such a burden.

The Infinite Possibilities That Lie in Invention.

In 1844, Commissioner Ellsworth, contemplating the 13,500 patents granted up to that year, over 500 of which were issued in the year 1843, and apprehending a cessation of all endeavors in the field of invention, uttered this prediction in his official report: "The advancement of the arts, from year to year, taxes our credulity and seems to presage the arrival of that period when human improvement must end." The commissioner could well marvel at the astounding advances made in labor-saving devices during his own life time, but what would have been his mental state could he have been endowed with prophetic vision and have foreseen but a fraction of the inventive activity which has taken place in a man's lifetime from the date of his utterance? The number of patents now is over a million, the annual issue is more than three times the number of all the patents granted up to his day, and the examining corps has increased from four to almost four hundred without being able to keep pace with the ever growing tide of new work. It is estimated that the value of American manufactures attributable directly or indirectly to patentable inventions amounts to the enormous total of more than twenty billion dollars, which is about four times the value of *all* taxable property in the United States at the time Commissioner Ellsworth made his report.


The United States of America.

To all to whom these Letters Patent shall come:

Whereas Peter Zacharie, a citizen of the State of Maryland, in the United States, hath alleged that he has invented a new and useful improvement in the mode of making nails and brads from cold iron

which improvement has not been known or used before his application; has made oath, that he does verily believe that he is the true inventor or discoverer of the said improvement; has paid into the Treasury of the United States, the sum of thirty dollars, delivered a receipt for the same, and presented a petition to the Secretary of State, signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for that purpose: These are therefore to grant, according to law, to the said Peter Zacharie his heirs, administrators or assigns, for the term of fourteen years, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used the said improvement, a description whereof is given in the words of the said Peter Zacharie himself, in the

In testimony whereof, I have caused these Letters to be made Patent, and the Seal of the United States to be hereunto affixed.

Given under my hand, at the City of Philadelphia this fourth day of May in the Year of our Lord, one thousand seven hundred and ninety six, and of the Independence of the United States of America the Twentieth.

G. Washington

By the President

Timothy Pickering Secretary of State

City of Philadelphia, to wit:

I do hereby certify, That the foregoing Letters Patent, were delivered to me on the fourth day of May in the year of our Lord one thousand seven hundred and ninety six to be examined; that I have examined the same, and find them conformable to law. And I do hereby return the same to the Secretary of State, within fifteen days from the date aforesaid, to wit: On this fourth day of May in the year aforesaid.

The first patents were signed by President George Washington.

It has been said that the single invention of producing steel by the Bessemer process doubled, directly or through its influence, the world's wealth in the third of a century after its introduction. The forcing effect of patent protection on industry is well illustrated in the cases of such branches as are directly based upon invention, and which did not exist or were in a negligible state in 1880.

Statistics for the Year 1909.

SOME OF THE INDUSTRIES CALLED INTO EXISTENCE SINCE 1880.

	Establishments	Persons engaged	Output annually	Value added by mfr.
Phonographs	18	5,928	$11,728,000	$8,667,000
Photo Apparatus	103	6,596	22,561,000	15,853,000
Cash Registers	50	9,491	23,708,000	20,156,000
Typewriters	89	12,101	19,719,000	15,642,000
Autos	743	85,359	249,253,000	117,506,000

The figures in the last column are particularly significant as they show the very high percentage added to the cost of the raw materials by the process of manufacture, i. e., by the knowledge, skill and labor of the producers.

More astounding are the figures relating to the electrical industries, including telephony, central station lighting and power, and electric railways, the latest figures available showing an investment in the United States alone of seven billion dollars, annual gross revenue or sales of over a billion, in which three quarters of a million men were engaged, at an annual pay-roll of over three hundred and fifty million dollars. These industries were either non-existent in 1880 or in their incipient stage at that time. Their origins and every advance therein were directly founded on inventions, every one of which is patented and of record in the Patent Office.

The Trend of Invention.

The activity of the different classes in the Patent Office from time to time reflects accurately the changes which constantly pass in the world of industry and the applied arts. The basic pursuit in this country always being the tilling of the soil, patents for agricultural implements have occupied a prominent position, both in numbers and importance throughout its history. The invention of the sewing machine initiated a period of great activity in a new art, while the telephone let loose a flood of inventions for adaptations and improvements. The new electro-chemical industry came into being about the middle of the eighties and patent activity with relation thereto was high at the same time. The incandescent lamp started the electric age, in whose vortex we still are, and patent concern in all things electrical is still intensive. The rise and fall of the bicycle, the wave of interest in automatic car couplings, the first surgings of activity in aeroplane invention, and the deep concern of the great ingenious to solve the urgent non-refillable bottle problem—all these movements have been reflected in the filing of applications in the Patent Office. In recent years the automobile is establishing records, the arts relating to internal combustion motors, carbureters, gearing, self-starters, accessories, alloy steels and heat treatment of steels being specially active.

The United States has by far the proudest record in the field of invention: whether reckoning by the number of pioneer products, their ingenuity, or their far-reaching effects in the greatest diversity of fields, she easily stands in first place. Particularly in labor-saving devices does she stand foremost. No one in all history has worked so hard to save labor as the Yankee. The greatest of all labor-saving devices, the sewing machine, is his, and outside of textile machinery, practically all the great advances in this department have been of his invention, as witness the cotton gin, the reaper, shoe machinery, typewriter and typesetting machines.

In the field of electricity the American shares pre-eminence with Europeans, and yet the three most signal advances in electrical application are to his credit—the telegraph, telephone, and the incandescent lamp. Since 1880 (the typewriter was invented a few years previously) no revolutionary mechanical invention comparable to those which signaled American ingenuity previously, was devised except the typesetting machine, but in the field of electricity (incandescent lamp, trolley car, electric welding), optics (kinetescope, transparent film) and air navigation (an absolutely new art), he did not remain inactive.

Some Prolific Inventors.

Between 1872 and 1900, Thomas Edison had received 742 patents; F. H. Richards, 619; Elihu Thomson, 444; Charles E. Scribner, 374; L. C. Crowell, 293; Edward Weston, 280; R. M. Hunter, 276; Charles J. Van Depoele, 245; and George Westinghouse, 239. Up to 1910 Edison secured 905 patents, of which 713 were electrical. Considering all the patents that are probably pending or in course of preparation, it is estimated that the number of his inventions is greater than 2,000. It is safe to assert that he is the most prolific inventor of all time.

Although Great Britain has more pioneer inventions to her credit involving fundamental operations that underlie all industry, than any other country, the only innovations of pioneer character she has contributed in the last one half century are the basic process for making steel, the steam turbine, and the cyanide process. But the steam engine, the greatest invention of all ages, is hers, and so is the Bessemer process, which inaugurated our present intensive industrial era.

Germany before 1871 was an almost negligible factor in the field of applied science, although she had previously to that date given ample evidence of her vigor in pure science. The adoption of a patent system based upon that of the United States, was an extreme stimulus to invention, and the impetus given to inventiveness is

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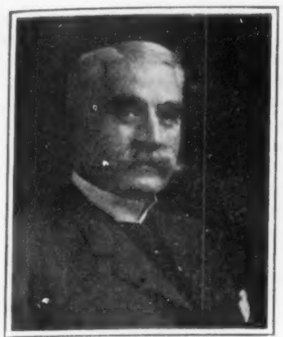
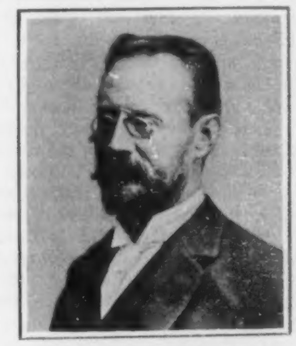


Charles F. Brush, inventor of the modern electric arc lamp.

Converting Night Into Day

Artificial Lighting Problems and How They Have Been Solved

What the Inventor Has Done for Oil, Gas, and Electricity in Illumination



Carl Auer von Welsbach, inventor of the Welsbach system of gas lighting.

WHEN Col. E. L. Drake "struck oil" in Pennsylvania in 1859 he also established the lamp oil industry. As soon as it was found that Pennsylvania had abundant supplies of oil the inventors began to file their applications for oil lamp patents. They began in 1859 itself and kept on for many years. Literally hundreds of lamps were invented. It was no mean problem to burn oil safely and efficiently in a lamp. Circular wicks and flat wicks, single burners and double burners, wicks of peculiar plaiting, were patented to feed the oil in just the right quantity to the burner head by capillary attraction. It is hardly worth while here to trace the course of development of the kerosene lamp. The simplest lamp soon proved the safest, all the more so since laws were passed in almost every country to prohibit the sale of oils with too high a flash point.

Arthur Kitson in 1885 patented a system of feeding the oil under pressure to a chamber where it was heated by the flame of the lamp itself and volatilized. The vapor thus produced was then fed to a kind of atmospheric burner, being automatically supplied by its suction with sufficient oxygen from the air to produce a very hot blue flame. Kitson employed a platinum gauze which was heated by this flame to incandescence, that being a time when the Welsbach mantle had not yet been commercially introduced. The gauze answered well enough for a time; but it became useless when soot was deposited upon its meshes.

But even if Kitson had been able to utilize the Welsbach mantle, his lamp might not have been successful in its early form. It is difficult to mix air with the high-pressure vapor so intimately that carbonization will not result, and a carbonized mantle is robbed of its luminosity. Even when the desired intimacy of mixture is obtained there is difficulty in maintaining it automatically. The difficulty was ingeniously overcome by F. Altmann, among others, who devised an arrangement in which water and oil were vaporized by a burner in a small separate chamber, whereupon the mixture of vapor and steam was fed to a special burner head, supplied with air, and used to heat a Welsbach mantle to incandescence. Such lamps are remarkably economical. They yield three times the amount of light which can be obtained from oil when consumed under ordinary conditions.

The invention of the Welsbach mantle served not only to improve the oil lamp, but also to revive "air gas"—air mixed with volatile hydrocarbons and burned in an Argand burner like ordinary illuminating gas of the present day. When the general extension of coal gas and electricity had practically relegated air gas to the place of an abandoned illuminant the Welsbach mantle gave it a new lease of life. A. I. van Vriesland, Hooker, and De Laitte are among the inventors who improved air gas generating apparatus so that the Welsbach mantle could be effectively employed.

The Development of Gas Lighting in Our Time.

Although towns were lighted early in the nineteenth century by gas, it was not until the last four decades that rapid progress was made in gas lighting; for in that brief period there were great improvements both in the manufacture of gas as well as in the methods of burning it. The London Argand burner of 1875 was considered the last word in illumination in its day—something that could not be surpassed. But when the incandescent mantle came, six times as much light was obtained from the same amount of gas. By 1845 most of the burners with which we are familiar had been invented and fairly well standardized. William Murdoch himself, the first man to use coal gas in his house (1779), devised the "cockspur" burner. J. B. Neilson devised the "fishtail" burner. Sir Edward Frankland in 1853 brought out his burner for utilizing the heat of the flame to raise the temperature of the air supply for the combustion of the gas. A similar regenerative system was that of the Rev. W. R. Bowditch (1854). By far the best of these regenerative burners was that of Friedrich Siemens, who came out with his invention in 1879. These ingenious burners, efficient as they were, never succeeded in supplanting the ordinary fishtail and batwing burner, simply because of their initial cost. The Argand burner, too, more than held its own.

It is obvious that these various burners depend for their efficiency on different principles. The ordinary fishtail or flat flame burner must be fed with a gas very rich in carbon particles. In the regenerative burners the temperature to which the carbon particles are heated is raised as high as the material of the burner will permit. It was the effort to increase this temperature and with it the efficiency of the gas flame that led to the evolution of the modern system of incandescent gas lighting.

While the principle underlying incandescent lighting—that of raising the temperature of refractory substances to a point where they emit light—is old and may be traced back fully a hundred years, it was not until our own time that it was successfully applied. To be sure, Gillard had tried to use platinum gauze so that he might increase the utility of his water gas, introduced in 1848, but his scheme failed because the platinum was coated with a deposit of carbon in a short time. Bunsen's invention of the burner that bears his name—a burner which produces a very hot, blue, almost non-luminous flame as a result of the mixture of air with gas—really made incandescent gas lighting possible. After that it was easy for Clammond, a Frenchman, to suggest the use of calcined magnesia as a refractory material to be heated by a Bunsen burner. Clammond created a sensation in the early eighties when he exhibited his system of incandescent lighting in London and Paris. He even used something like the modern mantle or stocking, although he called it a basket. What is more, he devised a creditable system of inverted incandescent lighting.

But it was not until Auer von Welsbach, a brilliant Austrian chemist, conducted his study of the rare earths that modern incandescent lighting was created. Although his discovery was to a certain extent accidental, still only a clear-seeing investigator could have seized upon that accident and turned it to practical account. During his spectroscopic study of the rare earths he used the platinum wire in the time-honored way. It occurred to him that he might obtain a more brilliant effect for his momentary purpose if he immersed a piece of cotton in the solution which he was investigating. To his astonishment, he found that while the thread was burned completely away, the salt of the solution into which it had been dipped still remained in the form of the original thread. What is more, that salt continued to glow with a wonderful brilliancy. Another experimenter might have passed the discovery by and continued with the main investigation. Welsbach realized the meaning of that brightly glowing thread, which was no longer cotton, but a metallic oxide. He set about the task of devising a fabric of cotton which could be used to soak up a solution of rare earth (zirconium, lanthanium, yttrium), and after much experimenting arrived at a mantle impregnated with thorium oxide mixed with other oxides. The really serviceable mantle came when he found that a little ceria must be added to the thoria in order to obtain a mantle capable of shedding the most light. All this investigation was conducted in the middle of the eighties.

The Evolution of the Welsbach Mantle.

When it was placed upon the market over twenty-five years ago the Welsbach mantle consisted of a knitted hose-like fabric of cotton, which was soaked in a liquid called lighting fluid—a solution of thorium and cerium nitrates in water. The cotton was burned out, leaving the thorium and cerium in the form of an ash, which was then hardened and shaped. To form a protective coating during shipment the mantle was dipped in a collodion solution.

The ash of the finished mantle has the same physical structure as the original fabric from which it was made, whether it be cotton or any other fiber. It is obvious, then, that the strength and other physical properties of the mantle depend very largely on the nature of the original thread. For perhaps a dozen years after the discovery of the incandescent mantle all mantles were made from cotton. In those days it was a miracle enough to make any kind of a mantle. The industry was absolutely new and was beset with numerous difficulties, both chemical and physical, and one of the earliest difficulties was the finding of a suitable fabric. Ramie was first introduced in mantle-making by Buhlmann in 1898. It has certain marked advantages over cotton, particularly in maintaining its candle-power, and to this day many mantles are still made from ramie. It was found by Knöfler in the early nineties that artificial silk (nitro-cellulose) was better than cotton for the manufacture of mantles, because the life of the mantle was more than doubled. It would be out of the question to use a material as inflammable as

The Jablochkoff "candle." Edison's first lamp. Brush's first arc lamp.

The Jablochkoff "candle" gave less light than many of the modern incandescents do. It embodied a "filament" at the top, the fusion of which started an arc. Edison's first lamp was the outcome of the most indefatigable experimenting in the history of modern invention. Brush exhibited his first arc lamp of the wonderfully simple and successful ring-clutch type in 1877.

Three interesting steps in the development of electric lighting.

nitro-cellulose for the manufacture of fabrics, without rendering it safe. Hence, the thread is denitrated. In other words, we start with cotton, change it to nitro-cotton, which we dissolve and form into threads, and then take out the "nitro" part, leaving the original cotton, but with an entirely different physical structure. Instead of the short, hollow, opaque fibers of the original cotton, we now have solid lustrous filaments of unlimited lengths. Changing the cotton to nitro-cotton is simply a trick to get it in solution. The remarkable nature of this material is realized when we consider that a thread weighing one pound will reach twenty miles. This thread in turn is composed of twenty strands, and if these could be separated and placed end to end, their total length would be 400 miles. Ten pounds would reach from Maine to California.

Simultaneously with Knöfler, de Lery (1897) and Plaissetty (1900) patented processes for mixing the thorium and cerium nitrates with a solution of nitro-cotton in ether and alcohol and squirting this solution through fine orifices. None of these schemes, however, turned out to be a commercial success. Plaissetty seems to have been the only one to persevere. Finally, he hit upon what seems the very obvious idea of making a knitted fabric of artificial fiber and saturating it in the lighting fluid directly. As nitro-cellulose is absolutely solid and rod-like in structure, it absorbs 50 per cent more than the sponge-like cotton and ramie, because it is colloidal in nature. To harden the mantle thus made Plaissetty used ammonia. He took out patents in Germany in 1902 and in this country in 1904. His process was a commercial success.

Since 1904 vast improvements have been made in the manufacture of mantles from artificial fiber. Nitro-cellulose fibers are much better than natural fibers, because they are absolutely uniform, because they are free from indissoluble impurities, because they can be made absolutely continuous, and because they are strong. An artificial fiber mantle will support a weight of one ounce suspended from its loop without breaking. This is a remarkable tensile strength for a product which, after all, is composed of nothing but ash. Cotton falls off in candle-power during the first 100 or 200 hours, and after 100 hours sustains a loss of about 25 per cent. Ramie depreciates less rapidly, but unlike cotton, the color of the light changes to a whiter shade. Artificial fiber mantles actually increase in candle-power during the first 100 or 200 hours, and there is no change of color in the light even after 1,000 hours of burning. Unlike natural fibers, artificial fibers do not shrink, nor do they deteriorate in strength nearly so rapidly as cotton or ramie mantles. Hence, the artificial fiber mantle may be said to mark a distinct advance in the art of mantle-making, perhaps the greatest since the introduction of the thorium-cerium mantle itself.

In the last twenty years high-pressure systems of incandescent gas lighting have been developed after much experimenting and study, the object, of course, being to obtain more light from a given amount of gas. Pumps are required to supply the gas under pressure, a floating bell being necessary to eliminate the fluctuations caused by the strokes of the pump piston. One of the principal systems of this type was invented by Sugg and is much used in Europe in cities where gas is on a competitive basis with the electric arc. Other systems have been devised by Lucas, Selas, and Keith.

To avoid the use of pressure apparatus, what are known as self-intensifying systems have also been invented. In these the lamp itself contains its own apparatus for supplying an increased quantity of air and gas. One of the most indefatigable inventors in this field is Lucas, who after much experimenting designed a chimney of such form that a very powerful draft is produced which acts on the gas flame and air, with the result that a very brilliant light is obtained. Other inventors depend on little pumps attached to the lamp to obtain their forced feed. Thus, in the Scott-Snell system the lamp's own heat drives a plunger, which forces gas to the burner under pressure.

Clammond, we have said, invented an inverted gas mantle during the course of his investigations. He recognized the fact that a vertical burner throws its light above the horizontal, whereas it is needed below, and that objectionable shadows are cast by the mantle supports and lamp parts. It was easier with his type of mantle to invert it than with the Welsbach. Clammond used an inverted blowpipe above his mantle and forced the air and gas down. To convert the ordinary Bunsen burner into a blowpipe simply blackens the mantle and is otherwise objectionable. What was needed was evidently some form of Bunsen burner which could be placed over a mantle and still operate under the usual pressure. H. A. Kent dodged the problem by inventing in 1897 a siphon-like Bunsen burner with the inlets for gas and air below the burner head so that there was no tendency for carbon deposition.

Otto Mannesmann, Bernt, and Cervenka discovered independently in 1903 that in the inverted incandescent gas lamp it was necessary to feed the mantle with a stream of mixture of smaller cross-section than that of the mantle itself and the importance of conducting the secondary air (air of combustion) toward the descending gas-air mixture. Not until this discovery was made could the inverted incandescent gas lamp be considered really practical.

The Evolution of Arc and Incandescent Lighting.

To my friend Munn Thomas A. Edison Orange Jany 10 1903.

Emil Rathenau, founder of the great *Allgemeine Elektricitäts Gesellschaft*, once told how he went to Paris in 1881, and at the electrical exhibition there saw the Edison exhibit. "The Edison system of lighting was beautifully conceived down to the very details and as thoroughly worked out as if it had been tested for decades in various towns. Neither sockets, switches, fuses, lampholders, nor any of the other accessories necessary to complete the installation were wanting; and the generating of the current, the regulation, the wiring with distributing boxes, house connections, meters, etc., all showed signs of astonishing skill and incomparable genius."

The arc lamp and the incandescent lamp bore many more points in common in the early days of electric lighting than they do now. "Early days" should be construed electrically, of course—say the seventies and eighties. For example, the first arc lamp to be extensively commercialized was the "candle" of Jablochkoff (1876), which gave less light than many of the modern incandescents do, and embodied a "filament" at the top, the fusion of which started the arc. On the other hand, among the earliest incandescent lamps were the so-called "incandescence-arc" lamps, based on the principle of an arc playing between two incandescent wires in a partially evacuated bulb.

Then, too, the "active material"—to borrow a battery term—of both families of lamps was basically the same, being carbon both for lamp filaments and arc electrodes for many years; but later invention and development have caused the two families to grow apart, introducing filaments of osmium, tantalum and tungsten, and arc electrodes of metal or of carbon impregnated with various salts. However, arc and incandescent lamps have for a long time been developing contemporaneously, side by side as it were, so that in looking back over their history we need not draw too sharp a line of demarcation between them.

In our historical review it is not necessary to follow the precedent of Irving, who starts his Knickerbocker History of New York with the creation of the world. Save for a passing reference to Benjamin Franklin's kite-flying experiment (1752), which may be regarded as the connecting link between electric light in nature and electric light as produced by man, we may start with Sir Humphry Davy, who in 1801 first observed and studied the phenomenon of the electric arc. At this time there was not a single central lighting station—either gas or electric—in the world; even matches were undiscovered. For his electrodes, Davy used rods of wood charcoal, heated and plunged into mercury to make them better conductors. The arc light was not publicly exhibited until 1809, when, the dynamo being unknown, Davy's mammoth battery of 2,000 primary cells at the Royal Institution, London, served as a cumbersome source of current.

We now pass to the fourth decade of the nineteenth century—a decade the discoveries and inventions of which were destined to advance electric lighting tremendously. The most important of these discoveries, without doubt, was the principle of electromagnetic induction, announced by Michael Faraday in 1831, while Director of the Royal Institution. Details of the experiments that Faraday made in arriving at this grand underlying principle on which electric generators depend are preserved in his laboratory note-books, and may be read in the published accounts of his life. The principle was not to find its broad commercial application, however, until several decades later. The year after Faraday's epochal observation was made, Hippolyte Pixii constructed a "dynamo," one of the first on record, consisting of a stationary electromagnet in which currents were induced by the rotation of a permanent horseshoe magnet.

It is undeniable that much more honor is generally due to the man who actually accomplishes a task than to him who first suggests the possibility of its accomplishment; nevertheless a great amount of credit rightly belongs to the theorist who has the insight or originality to suggest a certain line of activity. Thus, the carbon-filament incandescent lamp may be said, without detracting a whit from the labors of those who invented it, to have been born in the brain of Prof. Jobard of Brussels, who in 1838 suggested that a small piece of carbon, if incandesced *in vacuo* by electricity, might be employed as a lamp. He transmitted this idea to his pupil, De Changy, who did considerable experimenting without, however, producing a commercially successful lamp.

Coming to the fifth decade, we find commercial arc lighting dimly foreshadowed in 1844, when Foucault, experimenting with gas-retort carbon and using this in connection with a galvanic battery, produced such a steady and continuous light that he was able to use it for photographic purposes. Foucault's arc was the forerunner of a great many types of arc lamps that were to make their appearance from this time on until about 1860, none of which, however, combined the commercial requirements of simplicity and reliability to a sufficient degree to bring them into widespread use, especially at a time when the dynamo was idling away a protracted infancy in its cradle, the laboratory.

Among the freak types of arc lamp that passed into history during this early development period may be mentioned the Wright arc of 1845—the first arc lamp patented in England. This curious machine consisted of five circular carbon disks in series, of which two were movable by means of hand-screws serving to draw out the four arcs. No less awesome was the American arc-lamp of Wallace, in which the arc flame played back and forth over a linear space of about a foot, along a narrow gap between the opposed edges of two immense rectangular carbon slabs. One of these Wallace arcs is preserved in the National Museum at Washington; they were used commercially, in conjunction with the Wallace-Farmer dynamo, for street lamps in Baltimore

(*Concluded on page 575.*)

Some Personal Recollections

An Autobiographical Sketch

By Nikola Tesla

I AM glad to be accorded this opportunity for two reasons. In the first place I have long since desired to express my great appreciation of the SCIENTIFIC AMERICAN and to acknowledge my indebtedness for the timely and useful information which its columns are pouring out in a steady stream. It is a publication remarkable for the high quality of special articles as well as for the accurate review of technical advances. The knowledge it conveys is always reliable and rendered still more valuable through the scrupulous observance of literary courtesy in the quotation of the sources. The services it has rendered in helping invention and spreading enlightenment are inestimable. The SCIENTIFIC AMERICAN is a periodical ably and conscientiously conducted, measured and dignified in tone to the point of serving as a model, and in these features, as much as in the wealth and excellence of its contributions, it reflects great credit, not only on its staff and publishers, but on the whole country. This is not an idle compliment, but a genuine and well-deserved tribute to which I add my best wishes for continued success on this memorable occasion.

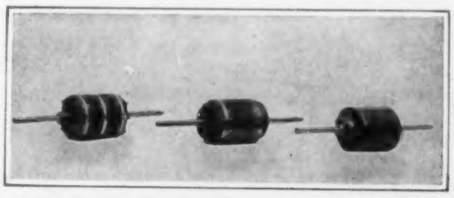
The second reason is one that concerns me personally. Many erroneous statements have appeared in print relative to my discovery of the rotating magnetic field and invention of the induction motor which I was compelled to pass in silence. Great interests have waged a long and bitter contest for my patent rights; commercial animosities and professional jealousies were aroused, and I was made to suffer in more than one way. But despite of all pressure and efforts of ingenious lawyers and experts, the rulings of the courts were in support of my claims for priority in every instance without exception. The battles have been fought and forgotten, the thirty or forty patents granted to me on the alternating system have expired, I have been released of burdensome obligations and am free to speak.

Every experience which I have lived through bearing on that early discovery is vividly present in my memory. I see the faces of the persons, the scenes and objects of my attention, with a sharpness and distinction and in a fullness of light which is astonishing, and is a measure of the intensity and depth of the original impressions. I have always been fortunate in ideas, but no other invention, however great, could be as dear to me as that first one. This will be understood if I dwell briefly on the circumstances surrounding it and some of the phases and incidents of my young life.

From my childhood I had been intended for the clergy. This prospect hung like a dark cloud on my mind. After passing eleven years at a public school and a higher institution, I obtained my certificate of maturity and found myself at the critical point of my career. Should I disobey my father, ignore the fondest wishes of my mother, or should I resign myself to fate? The thought oppressed me, and I looked to the future with dread.

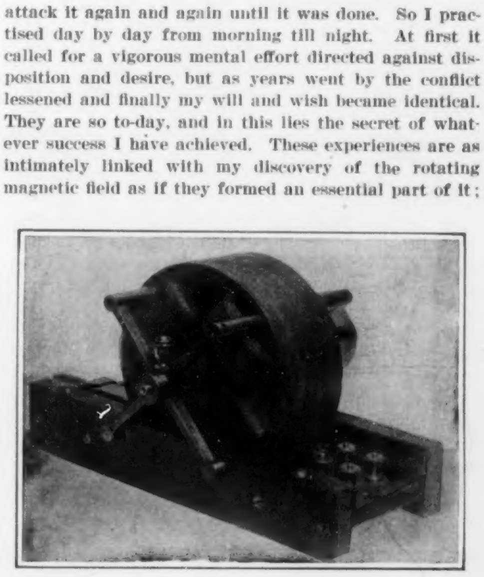
Just at that time a terrible epidemic of cholera broke out in my native land. People knew nothing of the character of the disease and the means for sanitation were of the poorest kind. They burned huge piles of odorous shrubbery to purify the air, but drank freely of the infected water and died in crowds like sheep. Contrary to peremptory orders from my father I rushed home and was stricken down. Nine months in bed with scarcely the ability to move seemed to exhaust all my vitality, and I was given up by the physicians. It was an agonizing experience, not so much because of physical suffering as on account of my intense desire to live. On the occasion of one of the fainting spells my father cheered me by a promise to let me study engineering; but it would have remained unfulfilled had it not been for a marvelous cure brought about by an old lady. There was no force of suggestion or mysterious influence about it. Such means would have had no effect whatever on me, for I was a firm believer in natural laws. The remedy was purely medicinal, heroic if not desperate; but it worked and in one year of mountain climbing and forest life I was fit for the most arduous bodily exertion. My father kept his word, and in 1877 I entered the Joanneum in Gratz, Styria, one of the oldest technical institutions of Europe. I proposed to show results which would repay my parents for their bitter disappointment due to my change of vocation. It was not a passing determination of a light-hearted youth; it was iron resolve. As some young reader of the SCIENTIFIC AMERICAN might draw profit from my example I will explain.

When I was a boy of seven or eight I read a novel entitled "Abafi"—The Son of Aba—a Servian translation from the Hungarian of Josika, a writer of renown. The lessons it teaches are much like those of "Ben-Hur," and in this respect it might be viewed as anticipatory of the work of Wallace. The possibilities of will-power and self-control appealed tremendously to my vivid imagination, and I began to discipline myself. Had I a sweet cake or a juicy apple which I was dying to eat I would give it to another boy and go through the tortures of Tantalus, pained but satisfied. Had I some difficult task before me which was exhausting I would



Three rotors used with the early Tesla induction motor shown below.

attack it again and again until it was done. So I practised day by day from morning till night. At first it called for a vigorous mental effort directed against disposition and desire, but as years went by the conflict lessened and finally my will and wish became identical. They are so to-day, and in this lies the secret of whatever success I have achieved. These experiences are as intimately linked with my discovery of the rotating magnetic field as if they formed an essential part of it;



One of the earliest of Tesla's induction motors.

Although it weighed only a little over 20 pounds, it developed ¼ horse-power at a speed of 1,800 revolutions, a performance considered remarkable at the time.

but for them I would never have invented the induction motor.

In the first year of my studies at the Joanneum I rose regularly at three o'clock in the morning and worked till eleven at night; no Sundays or holidays excepted. My success was unusual and excited the interest of the professors. Among these was Dr. Allé, who lectured on differential equations and other branches of higher mathematics and whose addresses were unforgetable intellectual treats, and Prof. Poeschl, who held the chair of Physics, theoretical and experimental. These men I always remember with a sense of gratitude. Prof. Poeschl was peculiar; it was said of him that he wore the same coat for twenty years. But what he lacked in personal magnetism he made up in the perfection of his exposition. I never saw him miss a word or gesture, and his demonstrations and experiments always went off with clocklike precision. Some time in the winter of 1878 a new apparatus was installed in the lecture room. It was a dynamo with a laminated permanent magnet and a Gramme armature. Prof. Poeschel had wound some wire around the field to show the principle of self-excitation, and provided a battery for running the machine as a motor. As he was illustrating this latter feature there was lively sparking at the commutator and brushes, and I ventured to remark that these devices might be eliminated. He said that it was quite impossible and likened my proposal to a perpetual motion scheme, which amused my fellow students and embarrassed me greatly. For a time I hesitated, impressed by his authority, but my conviction grew stronger and I decided to work out the solution. At that time my resolve meant more to me than the most solemn vow.

I undertook the task with all the fire and boundless confidence of youth. To my mind it was simply a test of will-power. I knew nothing of the technical difficulties. All my remaining term in Gratz was passed in intense but fruitless effort, and I almost convinced myself that the problem was unsolvable. Indeed, I thought, was it possible to transform the steady pull of gravitation into a whirling force? The answer was an emphatic no. And was this not also true of magnetic attraction? The two propositions appeared very much the same.

In 1880 I went to Prague, Bohemia, carrying out my father's wish to complete my school education at a university. The atmosphere of that old and interesting city was favorable to invention. Hungry artists were plentiful and intelligent company could be found everywhere. Here I made the first distinct step in advance by detaching the commutators from the machines and placing them on distant arbors. Every day I imagined arrangements on this plan without result, but feeling that I was nearing the solution. In the following year there was a sudden change in my views of life. I realized that my parents were making too great sacrifices for me and resolved to relieve them of the burden. The American telephone wave had reached the European continent, and the system was to be installed in Budapest. It appeared an ideal opportunity, and I took the train for that city. By an irony of fate my first employment was as a draughtsman. I hated drawing; it was for me the very worst of annoyances. Fortunately it was not long before I secured the position I sought, that of chief electrician to the telephone company. My duties brought me in contact with a number of young men in whom I became interested. One of these was Mr. Szigety, who was a remarkable specimen of humanity. A big head with an awful lump on one side and a sallow complexion made him distinctly ugly, but from the neck down his body might have served for a statue of Apollo. His strength was phenomenal. At that time I had exhausted myself through hard work and incessant thinking. He impressed me with the necessity of systematic physical development, and I accepted his offer to train me in athletics. We exercised every day and I gained rapidly in strength. My mind also seemed to grow more vigorous and as my thoughts turned to the subject which absorbed me I was surprised at my confidence of success. On one occasion, ever present in my recollection, we were enjoying ourselves in the Varos-liget or City Park. I was reciting poetry, of which I was passionately fond. At that age I knew entire books by heart and could read them from memory word by word. One of these was Faust. It was late in the afternoon, the sun was setting, and I was reminded of the passage:

> "Sie rückt und weicht, der Tag ist überlebt,
> Dort eilt sie hin und fördert neues Leben.
> Oh, dass kein Flügel mich vom Boden hebt
> Jhr nach und immer nach zu streben!
>
> * * * * * * *
>
> Ach, zu des Geistes Flügeln wird so leicht
> Kein körperlicher Flügel sich gesellen!"

As I spoke the last words, plunged in thought and marveling at the power of the poet, the idea came like

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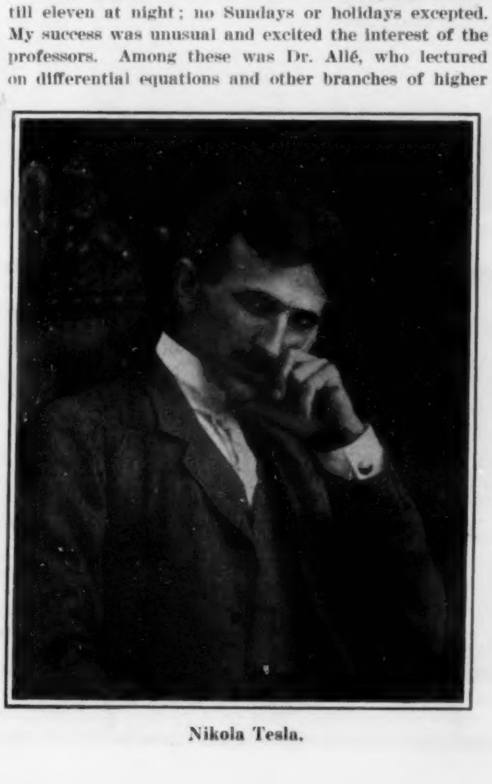


Nikola Tesla.

Machines With Which Machines Are Made

A Brief History of the Development of Metal-Working Power-Driven Tools

HOW nearly the SCIENTIFIC AMERICAN dates back to the very beginning of the machine tool industry in this country will be realized when it is known that the first planing machine was introduced into the country in 1830. Eight years later there were only four such machines in the United States, and when in 1845 the SCIENTIFIC AMERICAN began its weekly record of progress in the mechanical arts, there was no hint of the tremendous development of the American machine tool industry that was soon to follow.

In the very earliest days it was the textile machinery that provided the most work for machine tools. Then the Mexican war produced great activity in the arms and ammunition factories, which resulted in the building of many machine tools and the development of a number of important improvements. The civil war and the sewing machine industry furnished other chapters in the progress of machine tools, and by 1876 they had developed to such an extent as to form the most remarkable feature of the Centennial Exposition in Philadelphia. A glowing tribute to the ingenuity and resourcefulness of the American mechanical engineer was paid by Dr. John Anderson, who made a report to the British Parliament on machines and tools for working metal, wood and stone at the Exposition. He said: "The display of machine tools made by the United States was so vast that only the more salient points can be noted in a brief report. Americans as a rule are not copiers; the inventing of clever devices and tools for saving labor seems to be their natural forte, and, worthy of the old stock, they are probably quickened by the peculiarly favorable circumstances under which they live. It was the display made in this section which most conspicuously brought out the enormous strength of America as a producing power."

The textile industries continued to furnish the chief stimulus for the development of machine tools until the close of the century, when suddenly the automobile industry sprang into existence. At the same time the new high-speed tool steels were introduced. At the Paris Exposition in 1900 the public was astonished to see a machine taking such heavy cuts and at such a high speed that the shavings were at a blue heat, while the tool itself showed red hot even in daylight. Messrs. Taylor and White, two Americans experimenting with manganese and tungsten steel, had found a method of treating the alloys at high temperatures, which increased their efficiency greatly. The new steels increased the cutting speed of tools about 300 per cent. Immediately this had a wonderful influence upon the industry. Machines had to be redesigned to stand the enormous strains of taking such great cuts. At the same time the rapidly growing automobile industry furnished no end of capital for the development of all kinds of powerful and automatic machinery. The electric motor was introduced in the shop about this time, providing for individual drive, and hence a higher efficiency of operation.

Such in brief are the more important epochs in the development of machine tools.

Going back seventy years, we find that the lathe, the planer, the shaper, the slotting machine, the boring mill, and the drill had already been originated in England and introduced into this country. America's most valuable contributions to the machine tool industry were the turret lathe, which developed into the screw machine and the almost human automatic, and the milling machine, from which have grown certain types of gear cutting machines.

Some time between 1845 and 1853 Stephen Fitch, pondering upon a method of producing screws more cheaply, hit upon the idea of furnishing his lathe with a number of tools set in a holder which could be revolved to bring them successively to the working position. This was the first revolving turret lathe, but the turret had to be turned by hand. In 1855 a machine was produced by the Jones & Lamson Machine Company, which had mechanism for turning the turret automatically, so that after a cut was finished with one tool the turret revolved a step and without any attention on the part of the operator would present the next tool to the work, without destroying the adjustment of the first, which would remain ready for the next piece when its turn came.

The next important advance in the turret lathe was made in 1889 by James Hartness, and patents on it were granted in 1891, and again in 1904. This was the introduction of a flat style of turret, which carries the tool holders upon the top instead of about its periphery.

These tool holders are designed to take simple turning and boring tools somewhat after the manner of the tool post of an engine lathe, and thus reduce the amount of tool-making required and adapt the machine to the production of parts in small lots. In addition to this, long pieces may be used in the machine, since, there being nothing in the way to prevent, the turret may pass under the piece without interfering. Another feature of this lathe is the mounting of the headstock upon a cross-slide, which performs the function of the cross-slide of an engine lathe and permits facing, necking, and internal undercuttings to be done. The accompanying photograph shows the flat turret with cross-sliding headstock.

The machine is driven by a constant speed pulley, while in the headstock is a system of gearing which may be changed by means of the hand levers shown in the foreground of the photograph to provide nine different speeds.

In 1894 Conrad M. Conradson invented a lathe having a hole lengthwise through its spindle to adapt it for work "from the bar." The bar is of rough stock passed through the spindle and pushed forward and then gripped in the chuck after each piece has been finished and cut off. A tool slide having a crosswise movement only, though adjustable lengthwise of the lathe, is provided. This slide has two tool posts, of which the one in the rear, fitted with an inverted tool, may be used for cutting a recess, rounding a corner, etc., as the case may be.

A vertical turret lathe appeared in 1901. This was invented by E. P. Bullard. In this lathe a supplementary cross-slide turret capable of carrying four tools is provided. Observation stops are used. Large micrometer dials carrying adjustable indexes are attached to the feed screw shafts, the sizes of the work being determined by the matching of these indexes against stationary indexes. The sizes of the work dealt with make impractical the use of the usual special tools set for outer diameters. Accordingly, the tools used are like those used in engine lathes, the outer diameters as well as the lengths of the pieces made being determined by the observation stops.

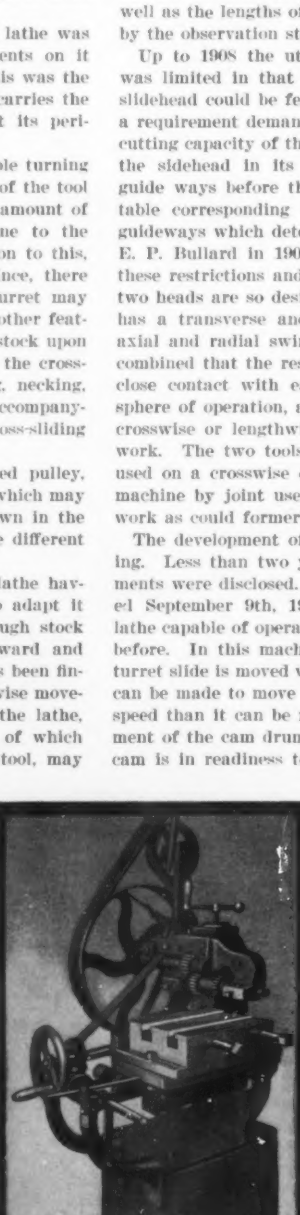
Up to 1908 the utility of the vertical turret lathes was limited in that the tool of neither crosshead nor slidehead could be fed at an oblique angle to the table, a requirement demanded by a large class of work. The cutting capacity of the side tool was also limited in that the sidehead in its upward travel struck the crossguide ways before the tool reached a height from the table corresponding to that of the underside of the guideways which determine the range of the vertical cut. E. P. Bullard in 1908 invented a machine eliminating these restrictions and limitations. In this machine the two heads are so designed that the cutting tool of each has a transverse and longitudinal movement the full axial and radial swing of the rotary table and are so combined that the respective tools may be brought into close contact with each other anywhere within their sphere of operation, and in that position fed conjointly crosswise or lengthwise of the axis of rotation of the work. The two tools, for example, may be conjointly used on a crosswise or lengthwise roughing cut. This machine by joint use of the tools does twice as much work as could formerly be done by either tool alone.

The development of the turret lathe is still proceeding. Less than two years ago two important improvements were disclosed. J. C. Potter in his patent granted September 9th, 1913, devised an automatic turret lathe capable of operating at a higher speed than known before. In this machine the mechanism by which the turret slide is moved when the cam is not acting thereon can be made to move the turret slide at a much higher speed than it can be moved by the cam, and the movement of the cam drum can be timed so that the proper cam is in readiness to begin its work the instant that the other slide-moving mechanism finishes its portion of the movement of the turret slide.

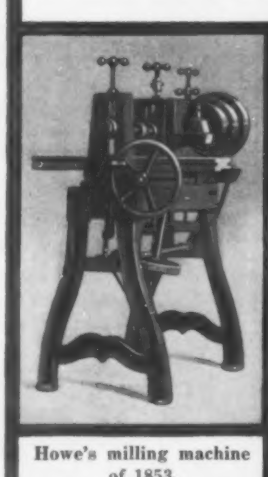
W. L. Miller was granted a patent December 16th, 1913, for an automatic turret lathe in which are two intermittently moving drums, each of which having applied thereto, in various positions thereon, cam blocks which in turn, as the drums are rotated, engage the lower ends of certain levers, the upper ends of which are connected to the several mechanisms through which changes of speed and direction of movement of the operating parts that engage the work are effected. The shaft on which these drums are mounted is connected with the pulley or main driving shaft of the machine through driving connections which are normally idle, but are adapted to be rendered active by certain trip devices automatically thrown into operation to move or index the drum around one or more steps by trips or projections carried by the several moving parts that are controlled as to their speed and direction of movement by the intermittently moving cam drums.

By this mechanism, the operator, knowing in advance the various opera-

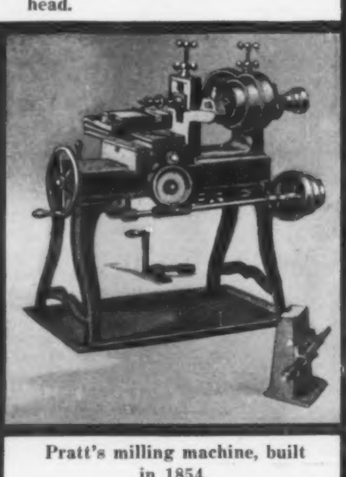
Flat turret lathe with cross-sliding head.



Typical milling machine of 1845.



Howe's milling machine of 1853.



Pratt's milling machine, built in 1854.

Brown's universal milling machine (1861).

tions to be performed upon a given piece of work, the tools to be used, the proper feeds to be given each tool, and the proper spindle speeds, sets the cams on the drums accordingly to produce automatically the predetermined movements and speeds; places the work in the chuck, and applies the power to the main shaft pulley. The machine then automatically performs these several operations in proper order or succession, and automatically stops when they are completed, leaving it to the operator only to remove the finished work and insert in the chuck a new piece of work. The utility of this improvement is obvious.

It was Eli Whitney, of the cotton gin fame, who in 1815 invented the first milling machine, and built a machine of this type at about that time in New Haven, Conn. When the SCIENTIFIC AMERICAN first came into being the milling machine had been improved to the extent of having vertical adjustment for the cutter spindle. A machine of this type is shown in one of the accompanying photographs. It was built by Gay Silver & Co. of North Chelmsford, Mass. In 1853 Frederick W. Howe, then in the employ of Robbins & Lawrence of Windsor, Vt., developed a milling machine which is the prototype of what has since been known as the Lincoln miller. The Lincoln miller was designed by F. A. Pratt of the Pratt & Whitney Company in 1854.

In 1861 Joseph R. Brown of the Brown & Sharpe Manufacturing Company developed the universal milling machine, which contained the vital principles of the universal milling machine of to-day. This machine was designed to cut spiral grooves in twist drills which had been worked out by hand prior to that date. The accompanying cut of the machine is reproduced from the SCIENTIFIC AMERICAN of December 27th, 1862. Many of these machines were built and sold during the Civil War, and following the Paris Exposition of 1867, where one was exhibited, a start was made in selling the American milling machine abroad. This was one of the factors leading to the establishing of an extensive business in American machine tools in foreign countries.

The most recent development in this type of machine is found in the semi-automatic machine of the Cincinnati Milling Machine Company. Two milling heads for simultaneous operations on both sides of the work are used, although single-head machines are also made by this company. The feature of these machines is the provision of an automatic quick return to the work table, and also an automatic increase in the forward movement for the numerous cases in which the surface to be machined is not continuous. A double set of dogs for controlling the feed mechanism is attached to the side of the work table. The work being properly chucked and one of the levers tripped, the table goes quickly forward at a rate of 100 inches per minute until the first surface to be machined reaches the cutter, when the motion automatically slows down to whatever feed has been selected, and this continues until one of the faces is milled. As soon as the cutter has passed this first face, the table automatically speeds up again to one hundred inches per minute, until the second face of the work reaches the cutter. Again the work proceeds at the speed selected, and, passing the second face, speeds up again, then slows down again when the third face is reached, feeds along the third face, and when this is completed, the table automatically returns at 100 inches per minute to the starting point.

Because of these movements the machine is semi-automatic, that is, the movements of the table are entirely automatic; but the chucking of the work and the starting and stopping of the machine are normally controlled by the operator.

The development of cylindrical grinding began about fifty years ago. Such grinding was done in a crude way as early as 1860. Owing to the necessity of finishing needle and foot bars for sewing machines, the Brown & Sharpe Company built a grinding machine which was put on the market in 1864 and 1865. This consisted of a 14-inch lathe with a wheel stand mounted upon the carriage. It was provided with a reversing speed mechanism. Ten years later came the universal grinder invented by Joseph R. Brown, which was exhibited at the Centennial Exposition.

During the early fifties hand-operated gear-cutting machines were in use, and in 1855 Mr. Joseph R. Brown designed and built a precision gear-cutting machine adapted not only for cutting gears, but for index drilling and circular graduating.

As is well known, there are three basic systems of gear cutting: the formed tool system; the generating system, of which the hobbing system is a development, and the templet system.

William Sellers & Co. in 1866 were the first to perform the functions of the tool system automatically, some of the machines then made being still in use in the Sellers shops. The first commercial automatic machine, however, was produced by Brown & Sharpe in 1877. In the latter machine the action is entirely automatic, the feed and return of cutter and the indexing of the blank from tooth to tooth requiring no attention on the part of the operator, who has but to remove the completed gears and supply their place with blanks.

The generating system of gear cutting was invented by Hugo Bilgram in 1884. The purpose of this machine was to produce bevel gears, for which at that time no satisfactory method of production was available.

In the first Bilgram machine the action was not fully automatic, but the later ones were. In these machines the straight-sided tool which represents one side of a rack tooth is mounted upon a ram driven precisely like a shaping machine ram. The gear blank is mounted below the tool upon a suitable arbor supported at its rear end by a conical segment which rolls upon a plane surface below it. The conical segment is a portion of the pitch surface of the gear to be cut, extended to the opposite nappe of the cone, while the plane surface is a portion of the pitch surface of the imaginary crown gear of which the cutting tool represents one side of a tooth.

The patents of J. E. Gleason in 1898, 1907, and 1910 disclosed many improvements on the Bilgram machine. In the Gleason machines the imaginary rack represented by two tools travels endwise with the feed, the gear blank turning upon its center, which does not change its position. The tools are mounted and reciprocate in guides on an arm which oscillates about the cone center of the gear blank cut, this oscillation being obtained by a horizontal yoke and vertical connecting rod. This yoke is secured to the main spindle and carries a segment gear, the pitch cone of this segment being identical with that of the gear blank being cut.

Mounted on the tool carrying arm is a second segment gear in mesh with the first. The second segment is a segment of a crown gear, its pitch plane being identical with that of the ideal crown gear tooth represented by the cutting tools. As the yoke oscillates it turns the gear blank with it, while the meshing of the segments compels the tool arm to oscillate and to carry the cutting tools past the blank in the same relation as a crown gear tooth in mesh with a tooth on the blank. The action of these machines is fully automatic.

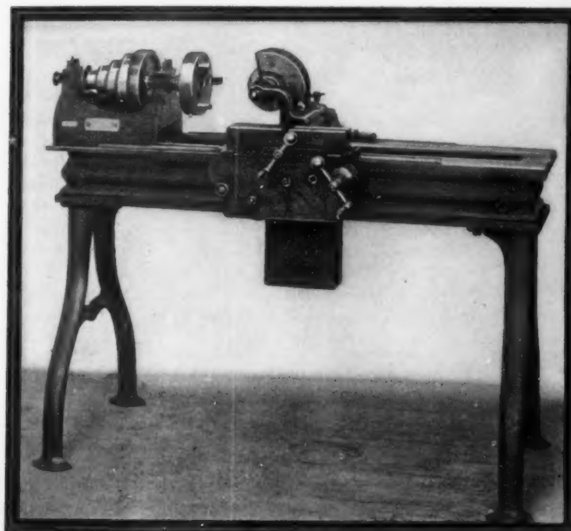
E. R. Fellows is the leading representative of the generating system in his patents of 1901, 1907, 1908, 1911, and 1912. In the Fellows machines the cutter and blank revolve slowly as the cutter reciprocates vertically. It also is generated from an ideal or imaginary rack tooth represented by the side of an abrasive grinding wheel, the final generation being done after the cutter is hardened. These machines are of the highest degree of precision.

The hobbing process of gear cutting is a modification of the generating system and was originally done in Germany. The hob is represented by a worm, which cuts the gear. In action the hob is adjusted at an angle such that the tangent to the helix is parallel with the teeth to be cut. The feed is double, that is, the gear blank revolves, and as it does so the hob is fed slowly across it. The cut is continuous, the gear being completed as the hob leaves its farther edge. By suitable adjustments helical gears may be cut with the same ease as spur gears.

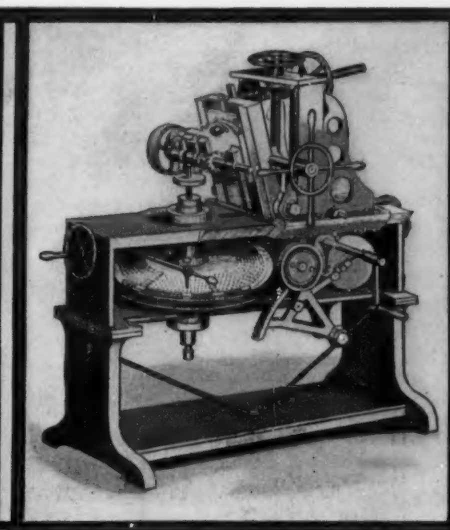
The templet system of gear cutting is most commonly used for large cut mill gears. Obviously, for such gears the cost of special cutters is prohibitive while a templet costs but little.

By a suitable feeding mechanism the tool is guided by rollers which ride on the templets. But one of the templets is in position at a time in actual use, thus avoiding interference with each other.

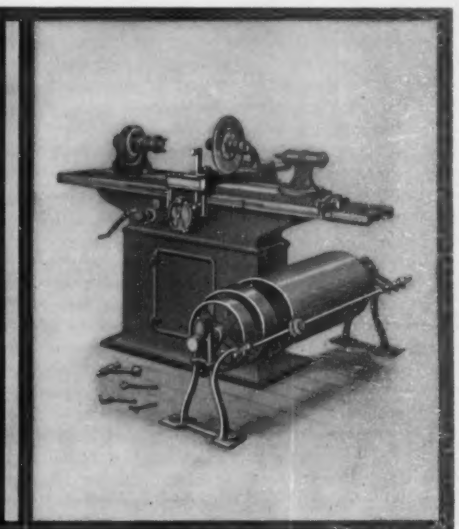
The application of the templet system to cutting bevel gears is done in the Gleason shops. The arm which carries the planing tool moves about the cone center of the gear to be cut, and its movement is guided by the templet on which a roller attached to the arm rides. The templet has the outline of the desired tooth profile suitably enlarged to provide for its increased distance from the cone center.



Photograph of cylindrical grinder put on the market in 1865. Some of the mechanism is missing.



Joseph R. Brown's machine for gear cutting, index drilling and circular graduating (1855).



Universal grinding machine of 1876, exhibited at the Centennial Exposition.

Such in brief is the story of machine tools down to the present day, but their history is not yet finished. American mechanical engineers are renowned the world over, and they are as active as ever in producing improvements and in making machines that will work steadily without the slightest attention, bringing one tool after another into action and turning out most intricate pieces of work, as long as they are supplied with the stock to work upon.

Some Early American Patents

IT is reported that the first American patent for a piano was issued to James S. McLean of New Jersey, May 27th, 1796; the first United States patent for washing machine was to Nathaniel Briggs of New Hampshire, March 28th, 1797; first United States patent for steam engine was to James Rumsey, August 26th, 1791; first United States patent for gas engine was to Samuel Brown of England, March 2nd, 1824; and that the first United States patent for air engines was to E. and J. Prentiss of Baltimore, June 22nd, 1824.

Richard M. Hoe's first United States patent for printing machine was granted May 20th, 1842, last patent April 27th, 1880.

John Ericsson issued his first United States patent February 1st, 1838, when he lived in Sweden; his second patent was issued November 5th, 1840, while he still resided in Sweden; a third patent issued in December, 1844, when he was living in New York; the last patent issued to him was on December 6th, 1887, while a later patent issued to his executors July 8th, 1890.

Thomas A. Edison's first patent issued June 1st, 1869, No. 90,646; many hundreds of patents have issued to him since that date, the Patent Office fees alone running up into thousands of dollars.

Alfred Ely Beach, Founder of Munn & Co.

Seventy Years of the Scientific American

How the Scientific American Was Founded and How It Grew from Very Small Beginnings; the Active Part Played by Its Editors in Stimulating Public Interest in Science and Invention

Orson Desaix Munn, Founder of Munn & Co.

TO picture adequately the part which the SCIENTIFIC AMERICAN has played for nearly seventy years would necessitate the writing of a complete history of modern science. So interwoven is the career of the greatest popular scientific paper ever published with the great discoveries and inventions that each issue, beginning with September 7th, 1845, may be regarded as a cross-section of the scientific knowledge of the day.

The SCIENTIFIC AMERICAN as we know it to-day is a monument to the untiring energy and enthusiasm of Mr. Orson D. Munn and Mr. Alfred E. Beach, who composed the original partnership of Munn & Co.

Mr. Beach had been brought up in the offices of the New York *Sun*, of which his father, Moses Yale Beach, was the proprietor. It was but natural that the first office of Munn & Co. should have been located in the old Sun Building, on the corner of Fulton and Nassau streets, in New York city.

The first issue, which bears the date September 7th, 1845, was about as large as a modern daily newspaper. There were only four pages. That first issue boldly declares that "The SCIENTIFIC AMERICAN is the advocate of industry and the journal of mechanical and other improvements." Apparently there was not much industry to advocate or many mechanical improvements to record; for the editor found space enough to publish poetry, dissertations on temperance, and brief articles on such curious topics as "The Utility of Tribulations,' "The Evil Influence of Fashion," "Street Beggars," "Oriental Servility," and "Church Benevolence."

When the SCIENTIFIC AMERICAN was first published the great achievements of the century were Davy's discovery of the electric arc light and of electrolysis; Oersted's and Ampere's electro-dynamic discoveries; Daguerre's method of photographing; Henry's and Faraday's discoveries in induction; and Joule's determination of the mechanical equivalent of heat.

Restraining the Advertiser.

As interesting historically as the editorial pages are the advertising columns of the SCIENTIFIC AMERICAN. Among the first advertisements that appeared was one of Adams & Co., offering to transmit "valuable packages and parcels of every description" from Philadelphia to New York at the unprecedented rate of three days. The modern kodak advertisement finds its counterpart in advertisements of apparatus for making daguerreotypes. By 1849 the advertisements had increased so alarmingly that the publishers considered it their duty to apologize in the issue of May 5th, 1849, for printing the unpardonable number of two and one half columns of advertising. To restrain the advertiser as much as possible, there appeared for some years at the head of the advertising section of the SCIENTIFIC AMERICAN a notice (it was almost a warning) that read:

Patent Department of Munn & Co. in 1849. From a contemporary print.

The Scientific American offices at 37 Park Row, 1859-1882.

One square of eight lines, 50 cents for each insertion.
One square of 12 lines, 75 cents for each insertion.
One square of 16 lines, $1 for each insertion.
Advertisements should not exceed sixteen lines, and cuts cannot be inserted in connection with them at any price.

Time and the increasing importance of advertising in modern journalism changed that haughty attitude. "Display copy," as it is now called, was accepted in any amount in the late seventies.

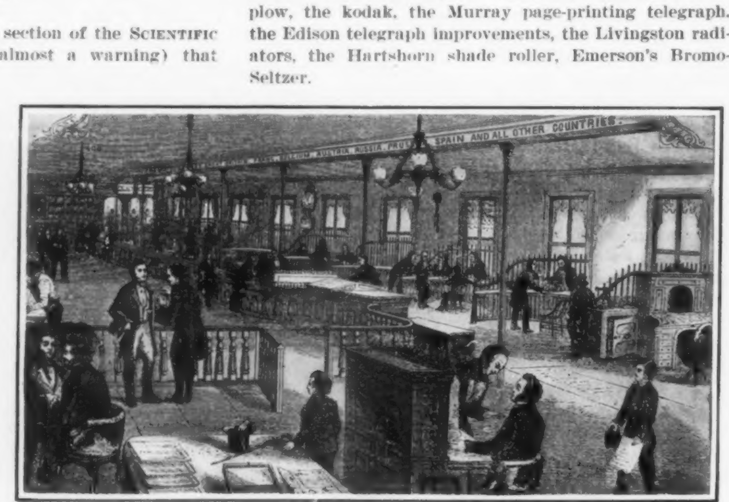
It is curious the way in which firms, then small but now colossal, announced their readiness to serve the public. The Lamb Knitting Machine Company, the Otis Elevator Company, Jones & Laughlin, the American Bell Telephone Company, the Westinghouse Company, corporations now of international importance, stated the nature of their business with the formal politeness and ceremonious phraseology of a wedding invitation. Later, when the psychological effect of advertising was better understood, they become more direct, more personal in their appeal. One of the pioneers in that direction was George B. Eastman, who selected the SCIENTIFIC AMERICAN as the first medium in which to advertise the kodak.

How the Patent Department Was Created.

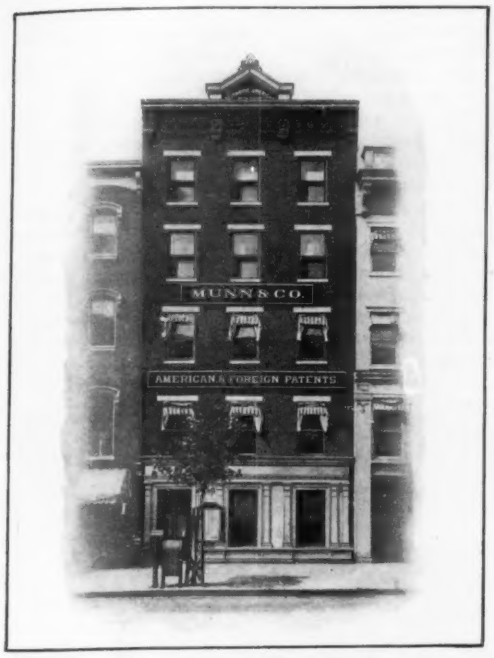
Because it was the only scientific paper of its kind, the offices soon became a meeting place for inventors. Out of this intimate relation sprang the necessity of creating a special department for inventors, a department to give advice on the patenting of inventions and on patent law. From its very inception that department has proved the most successful patent agency ever established. Among its clients have been such distinguished men as Samuel F. B. Morse, inventor of the telegraph; Elias Howe and A. B. Wilson, famous for their sewing machine inventions; Capt. James B. Eads, the distinguished builder of the great Mississippi bridge; Capt. John Ericsson, designer of the "Monitor"; Dr. R. J. Gatling, inventor of the Gatling gun; Peter Cooper Hewitt, inventor of the mercury arc light; Cornelius Vanderbilt, Col. J. J. Astor, Dr. Leo Baekeland, the chemist; Henry Guy Carlton, the dramatist, and Thomas A. Edison.

Some of the inventions patented by these men and others have been noteworthy. Among them may be mentioned the mercury arc light, the centrifugal snow plow, the kodak, the Murray page-printing telegraph, the Edison telegraph improvements, the Livingston radiators, the Hartshorn shade roller, Emerson's Bromo-Seltzer.

United States Patent Office and Munn & Co.'s first office in Washington. (From an old print of 1859.)



Interior of Scientific American offices at 37 Park Row, 1859-1882. Here many famous inventors of the day came for advice.



Scientific American Building, Washington.

Is it any wonder that inventions which have proved the foundations of great industries were thus first brought to the notice of the publishers of the SCIENTIFIC AMERICAN, long before the general public, or even the Patent Office, ever heard of them?

A. B. Wilson and the Sewing Machine.

Thus, one day, A. B. Wilson, a journeyman cabinet maker, came from Pittsfield, Mass., to lay before the SCIENTIFIC AMERICAN the model of a sewing machine. He had been derided by his neighbors, all of whom regarded it as rather foolish to sew by machine. His invention proved to be a distinct improvement in the art, and its four-motion feed, eventually embodied in the Wheeler & Wilson sewing machine, made its inventor wealthy. The world first heard of it through the SCIENTIFIC AMERICAN of November 24th, 1849.

Thomas A. Edison, too, was a visitor in the early days of his brilliant career. In 1877, he came to the office and placed before the editors a small machine, about which he offered very few preliminary remarks. He turned a crank and, to the astonishment of everyone present, the machine said: "Good morning. How do you do? How do you like the talking box?" That was the first public audience to which the modern phonograph ever addressed itself. So, too, the SCIENTIFIC AMERICAN editors were among the first who ever saw the electric incandescent lamp, the kinetoscope, the Edison dynamo, and the score of famous inventions with which the name Edison is now identified.

Alfred E. Beach's Scientific American Tunnel.

The proprietors of the SCIENTIFIC AMERICAN took more than a journalistic interest in invention. One of them, Mr. Alfred Ely Beach, was an inventor of note himself. To him we owe one of the first really successful typewriters and the first practical attempt at tunneling by means of a shield.

It was the transportation problem of New York, a problem which seems to have given as much concern in 1845 as it does now, that aroused the interest of the SCIENTIFIC AMERICAN in the possibility of constructing rapid transit subways. When hardly four years old, the SCIENTIFIC AMERICAN began the agitation of a rational engineering solution of New York's problem. In the issue of November 3rd, 1849, appeared an editorial entitled "An Underground Railroad in Broadway," in which we read:

"The plan is to tunnel Broadway through the whole length, with openings in stairways at every corner. This subterranean passage is to be laid down with a double track, with a road for foot passengers on either side—the whole to be brilliantly lighted with gas. The cars, which are to be drawn by horses, will stop ten seconds at every corner, thus performing the trip up and down, including stoppages, in about an hour."

Year after year the SCIENTIFIC AMERICAN, in company with the newspapers of the day, berated the city authorities for their negligence in providing adequate transportation. Finally, Mr. A. E. Beach determined to attack the problem himself. Time and time again he had advocated the construction of a subway, only to be derided in the public press. His proposals must have been very exciting, for the New York *Times*, in its issue of March 15th, 1869, protested:

"It is said that the city is quite likely to grant a charter to build what is called an arcade railroad under Broadway. We would scarcely believe it. When this wild scheme was dismissed a year or two ago, we hoped and believed that we had heard the last of it—and so did everybody else."

Eventually Mr. Beach secured legislative authority to build a pneumatic tube from Warren to Cedar Street, through which parcels were to be blown from one end to the other.

Obtaining a franchise meant the paying of tribute to the politicians of the day. Mr. Beach, therefore, determined to build his subway furtively, without the formality of asking for a franchise. In six nights, a gang of men had secretly dug out a tunnel extending from Broadway and Warren Street to Broadway and Murray Street. The dirt was carried to the cellar of a structure that occupied the site on which the Rogers-Peet Building now stands, and dumped there. A *Tribune* reporter, disguised as a workman, gained access to the subway. On the following day his paper published a complete exposure of the scheme. New York shared Horace Greeley's astonishment and indignation. To counteract the *Tribune's* attacks, and to prove to the public that the scheme was not utterly impracticable, Mr. Beach decided to throw the subway open to the public and to permit a general inspection of the tunnel, with its car and the big machine that blew the car from one end of the tunnel to the other. An admission fee of 25 cents was charged, and the proceeds were given to charity.

New York Office 1883-1915.

On January 31st, 1882, the Scientific American Building on Park Row was destroyed by fire.

Copyright by B. G. Mitchell.

The Scientific American's new home in the Woolworth Building.

What New Yorkers saw is thus described in the SCIENTIFIC AMERICAN of February 19th, 1870:

"Let the reader imagine a cylindrical tube, eight feet in the clear, bricked up and whitewashed, neat, clean, dry, and quiet. Along the bottom of this tube is laid a railroad track, and on this track runs a spacious car, richly upholstered, well lighted, and with plenty of space for exit. The whole arrangement is as comfortable and cozy as the front basement dining-room of a first-class city residence. The tunnel has not only the positive comforts described, but is absolutely free from the discomforts of surface car travel. The track is single and level. It is not cold in winter. It will be delightfully cool in summer. . . . The air will be constantly changed in it by the action of the blowing machine. The filthy, health-destroying, patience-trying street dust, of which uptown residents get not only their fill, but more than their fill, so that it runs over and collects on their hair, their beards, and eyebrows, and floats in their dress like the vapor on a frosty morning, will never be found in the tunnel."

On the first day, a great stream of people passed through the tunnel, 21 feet beneath Broadway. At the Murray Street end stood the car. It fitted the tunnel like the carrier of a pneumatic tube, which it really was. The tunnel itself was "brilliantly illuminated" by gas, as one enthusiastic contemporary account remarks. Eighteen persons at a time took their seats in the car, were blown from one end of the tunnel to the other by compressed air from a 100 horse-power plant, and were sucked back when the blowing apparatus was reversed.

For a year the car traveled back and forth beneath Broadway. It was Mr. Beach's intention to excavate the whole length and breadth of Broadway, to lay his tracks, and to restore the street by building a roof over the trench—a complete anticipation of the "cut and fill" method which was actually adopted in constructing the present subway, many years afterward. New York was convinced. The *Times* ended by approving the system. But when Mr. Beach tried to have a bill passed authorizing him to complete his scheme, he found himself face to face with Tammany Hall. His bill was passed, but so was a Tammany bill, authorizing the construction of an elevated railroad at a cost of five million dollars, to be paid out of the city treasury. A Tammany Governor vetoed the Beach measure and signed the Tammany bill. The newspapers that had at first bitterly opposed the subway were in a rage. There was nothing for it but to close the short tunnel that had actually been built single-handed by the editor of the SCIENTIFIC AMERICAN.

After this experience, it is not astonishing

that the elevated railroad was hotly opposed in the columns of the SCIENTIFIC AMERICAN. The arguments advanced against the present structure that disfigures two of New York's principal avenues can be more fully appreciated now than they were then, verified, as they have been, by time and experience.

Advocating Better Railways.

Year after year, the SCIENTIFIC AMERICAN urged the need of better and speedier transportation, not only in the city of New York, but throughout the country. It performed a useful service in advocating the construction of transcontinental railways. As early as 1849 it began to agitate the advisability of linking the Atlantic and Pacific coasts by rail, and played a conspicuous part in the press campaign that molded public opinion and eventually brought that great undertaking to a successful consummation.

The possibilities of the Panama Canal, too, were early pointed out. In the very year of its foundation, the SCIENTIFIC AMERICAN broached the subject of the utilization of the Isthmus. The first projects proposed in the editorial column advocated a railway on which ships were to be bodily transported across the Isthmus. "Let a permanent double-track railway be constructed," said the SCIENTIFIC AMERICAN of November 28th, 1846, "and supplied with 32-wheeled cars; and ordinary merchant vessels may be transported from the Atlantic to the Pacific, or *vice versa*, in from ten to twenty hours." Hardly a year passed but some reference was to be found in the editorial columns of the vital importance of connecting the Atlantic and Pacific oceans.

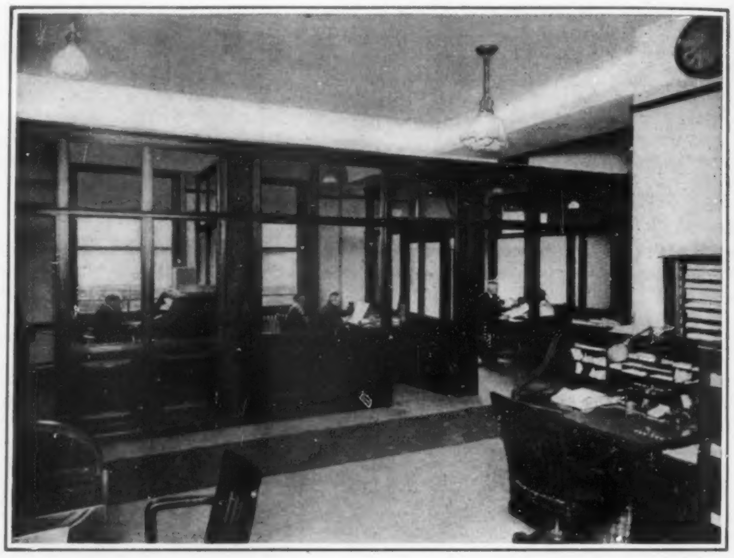
The Scientific American and the Automobile.

The automobile has been a familiar vehicle on our public streets only for the past twelve years. Forty years before its advent the SCIENTIFIC AMERICAN was publishing articles on the motor car, beginning with the fifth issue in 1845. Year after year, space was given to the ideas of inventors who knew that some day the motor-driven vehicle would displace the horse—gropings in the blackness of futurity, most of them; wonderful glimpses of later developments, many of them; poetic visions of meshing gea s and puffing engines, all of them. It was through the SCIENTIFIC AMERICAN that the United States first heard of Cugnot, Trevithick, Guerney, Church, and Lénoir. When the automobile did appear at last, it seemed to its readers not like a sudden apparition, but as a vehicle with which they had always been familiar.

The Scientific American and Aerial Navigation.

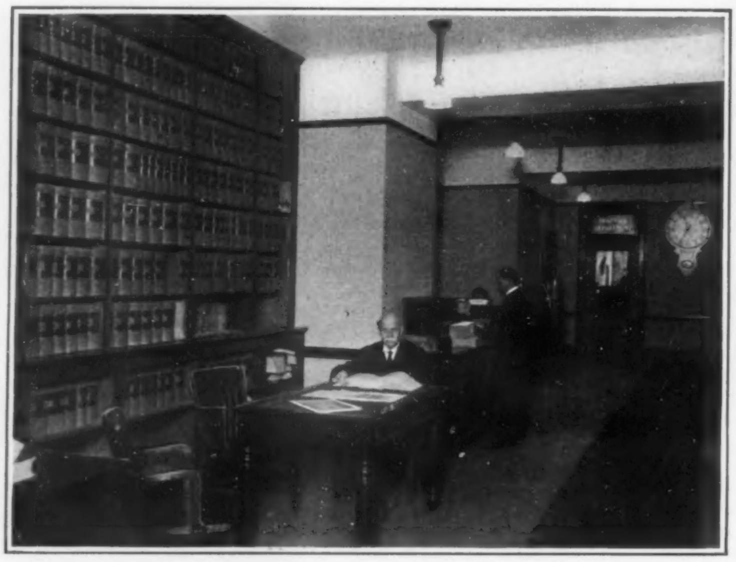
Simultaneously with articles on automobiles appeared articles on aerial navigation. The SCIENTIFIC AMERICAN

New offices of Munn & Co., in the Woolworth Building.



Three of the fourteen private offices of Munn & Co.'s patent staff.

Where the draughtsmen prepare patent drawings.



Library and Waiting Room, Main Office.

The Book Department.

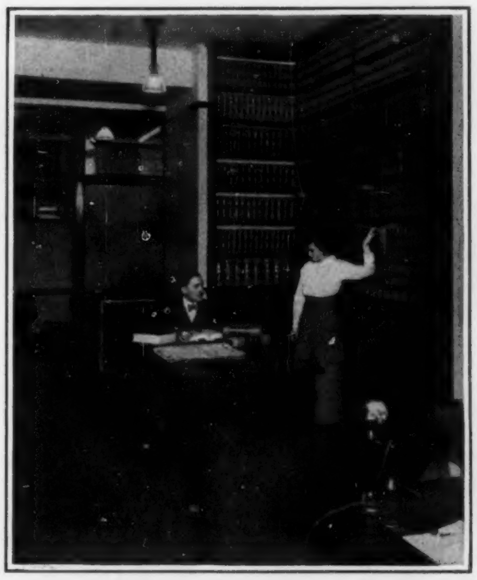
Where the correspondence, models and other records are filed.

was only four numbers old when its editor announced his intention of constructing a dirigible airship 350 feet long and 35 feet in diameter, a long cigar-shaped craft, that may well be regarded in some respects as an anticipation of our modern dirigibles. "To drive it," said the Editor, "we have already constructed and put in operation a steam engine and boiler, capable of working two horse-powers, but weighing only 200 pounds." He had the safety of his passengers in mind, too, for "the balloon," he states, "will be furnished with an improved parachute for each passenger, of which each may avail himself in less than one minute in case of extraordinary emergency, and thus descend safely on *terra firma*, much easier than he could paddle himself to shore on a cotton bale even from the middle of Long Island Sound." Encouraged by the Editor's optimism, inventors of aeronautic machinery turned to the SCIENTIFIC AMERICAN for advice and criticism. For over half a century it was the only periodical in this country that took the airship and aeroplane seriously and that devoted any amount of space to aerial navigation. Hence it was that the most distinguished aeronauts of the day were personal friends of the Editor. Among them was John Wise, the Nestor of American balloonists. He was not always pleased with the Editor's strictures, and voiced his disapproval in a spirited letter published in the issue of October 13th, 1849.

Although it believed in aerial navigation, the SCIENTIFIC AMERICAN performed a useful service by mercilessly ridiculing the more preposterous flapping wing machines and screw fliers and by publishing simply worded, accurate information for the benefit of the inventor of airships and flying machines.

And so the SCIENTIFIC AMERICAN contributed its share to the development of this newest of all methods of transportation, contributed it, moreover, by playing the part of an open-minded tutor. When the dirigible was scoring its first successes, and the heavier-than-air machine figured only in novels, the SCIENTIFIC AMERICAN insisted that the aeroplane was the air vehicle of the future. Langley's unsuccessful attempt to launch his man-carrying machine in 1903, was made the subject of derisive editorials in almost every newspaper of the country. The SCIENTIFIC AMERICAN alone defended Langley, and pointed out that his aeroplane was no more defective than a ship which had never been launched.

It is true that the Wright brothers were regarded with a skeptical eye at first; but that was because they flew in secret and would tell nothing. Later, when the SCIENTIFIC AMERICAN made an investigation and questioned citizens of Dayton, who had actually seen the machine fly, it became the Wright brothers' staunch support. What is more, the publishers offered the SCIENTIFIC AMERICAN $2,500 Trophy for flights by heavier-than-air machines, the first aviation prize of its kind in this country. Designed as a challenge trophy, the winning of which was to be made increasingly difficult as the art of flying progressed, the prize passed finally into the hands of Mr. Glenn H. Curtiss in 1910. When Mr. Edwin Gould cast about for a medium through which he could offer a prize of $15,000 "for the most perfect and practicable heavier-than-air machine . . . equipped with two or more power plants," he selected the SCIENTIFIC AMERICAN, for reasons that must have seemed obvious to those who knew how great a part the paper had played in recording the development of the flying machine.



The Law Library of Munn & Munn.

No less interesting to those who directed the destinies of the SCIENTIFIC AMERICAN than aerial navigation was the development of the modern battleship. From the year in which Ericsson's "Monitor" was launched (of which primitive craft the SCIENTIFIC AMERICAN published what was long the only authoritative picture) to the present day, every improvement in the ironclad fighting ship has been noted.

The Scientific American and Its Subscribers.

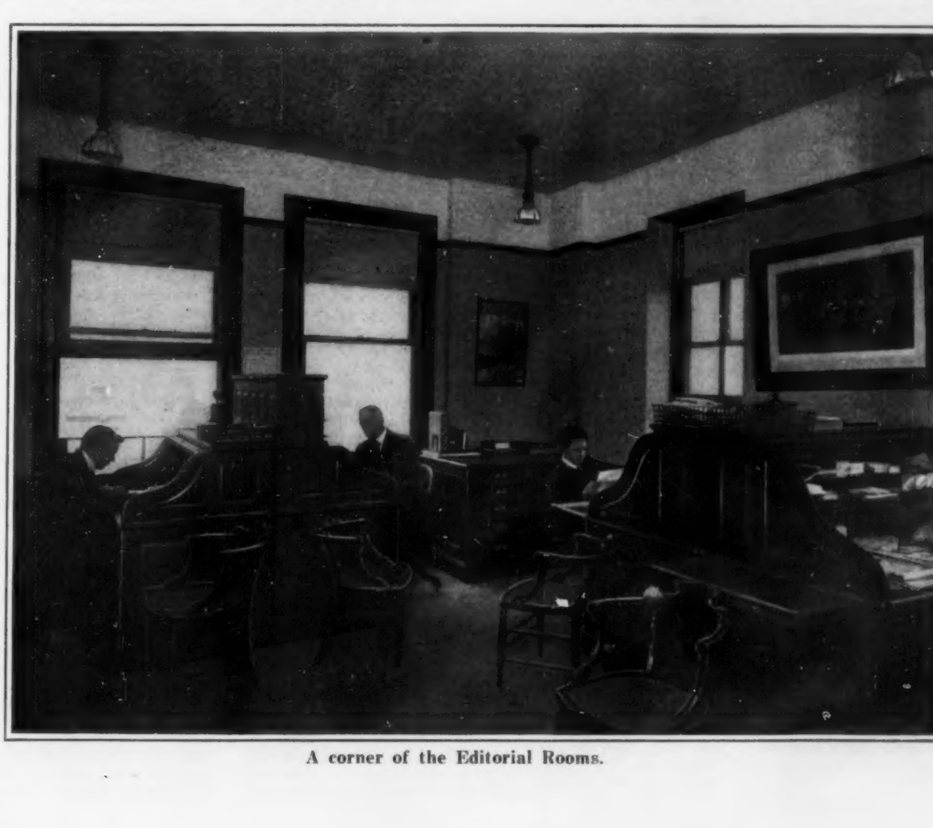
From the very inception of the SCIENTIFIC AMERICAN, the editor and the subscribers have been more closely connected than is usual, even in these days of paternal magazine editing. The periodical was always regarded by the publishers as something more than a mere commercial venture. They have always felt that they owed a duty to the subscribers, and a duty that did not end in giving an amount of printed matter equivalent in value to the price of an annual subscription. Accordingly, no letter asking the editor for information is allowed to go unanswered. Often the response entails an amount of research worth many times the amount of the subscripcion. As a mark of appreciation of the services thus rendered, Mr. T. R. Bowman of Adelaide, South Australia, voluntarily presented the SCIENTIFIC AMERICAN with a gold medal in 1899. The letter that accompanied his gift, which is probably unique in the history of magazine publishing, reads:

"I forward this trifle to the editor of the SCIENTIFIC AMERICAN as a souvenir of thanks for the many favors, information, and instruction I have derived from the perusal of the SCIENTIFIC AMERICAN for the last twenty-seven years; also for your kindness in giving me at different times information by letter."

For several decades the SCIENTIFIC AMERICAN stood practically alone in the particular field which it covered. Launched in a new country, destitute of great libraries, great museums, or great universities, it served to a limited degree, it may be, but with distinct success, the purposes of all three. Not a few of the men who stand at the head of the great industrial institutions of the United States recall the hopeful days of their boyhood and their young manhood, when their chief source of instruction in the great happenings of that world in which they were about to make venture was the SCIENTIFIC AMERICAN. Thousands of men who are now engineers and manufacturers received their first inkling of mechanical electrical engineering from the pages of the SCIENTIFIC AMERICAN. Thomas A. Edison has related that as a boy he used to walk three miles every week to get his SCIENTIFIC AMERICAN. For nearly seventy years, issue after issue has explained with a simplicity that has appealed to every earnest student, unfamiliar with the phraseology of

Subscription Department of the Scientific American publications.

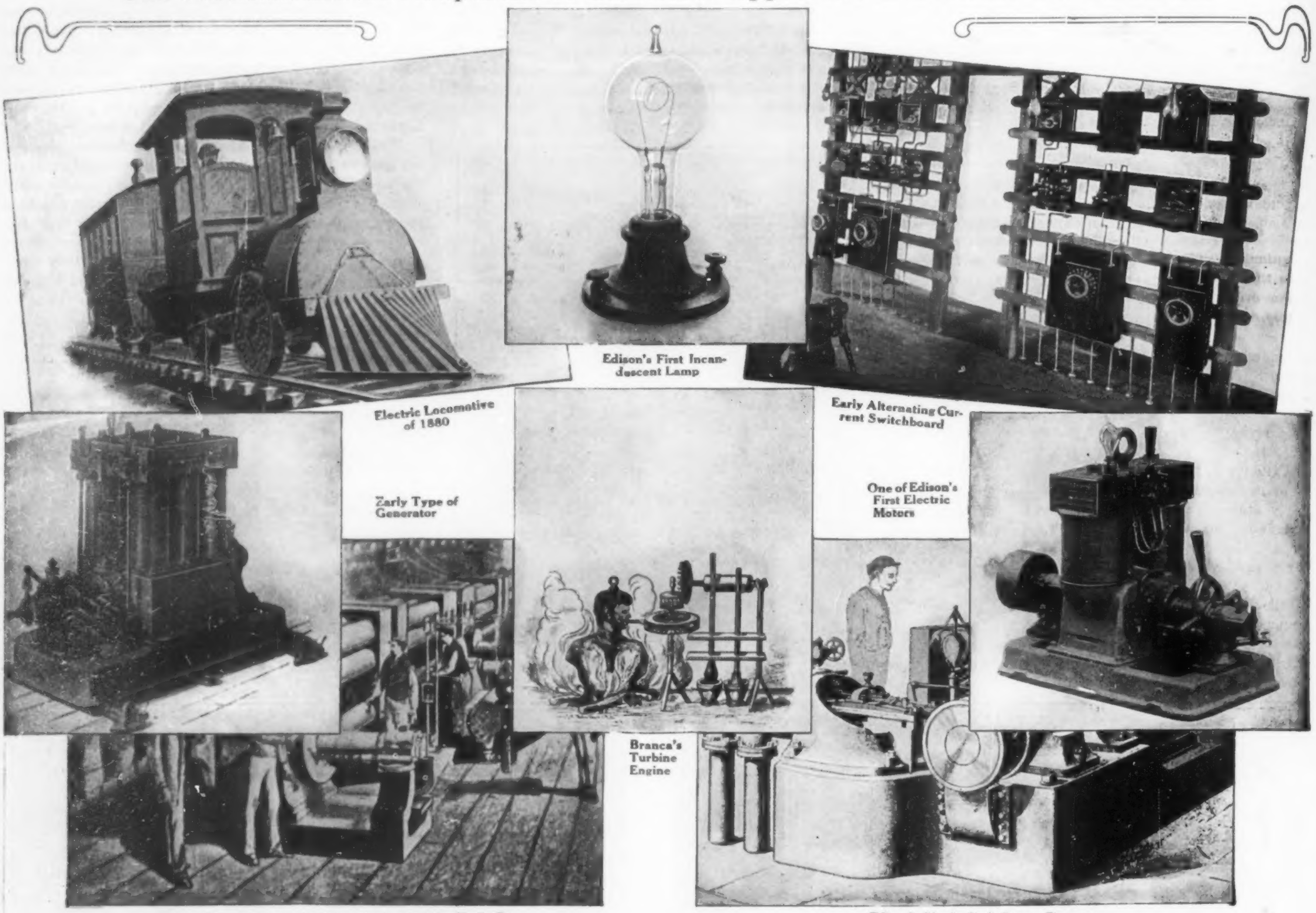
The Advertising Department of the Scientific American.



A corner of the Editorial Rooms.

MAKING A NEW INDUSTRY

The Phenomenal Development of Electrical Apparatus in the Last Two Decades



Electric Locomotive of 1880

Edison's First Incandescent Lamp

Early Alternating Current Switchboard

Early Type of Generator

One of Edison's First Electric Motors

Branca's Turbine Engine

First Edison Electric Lighting Station in New York City

Edison's Menlo Park Steam Dynamo

Only a few years ago Edison perfected the first incandescent electric lamp and built the first central distributing station in New York City. The advance of the electrical industry from this humble beginning, which is depicted above, has been truly wonderful.

THE great industrial development of electricity began when the General Electric Company was organized in May, 1892. This marked the birth of a new industry, which was destined to become the marvel of the age in a few short years. Never in the history of manufacturing had such progress been recorded. Invention followed invention, discovery added to discovery, until it seemed as though the public was introduced to new electrical achievements every day.

The consolidation of several minor and struggling electric concerns into the General Electric Company was for the purpose of bringing together and harmonizing divergent methods and, by uniting different patents, of securing a more perfect product. Up to that hour, electric lighting, electric power and electric traction had remained in the experimental stage. Never before in the industrial world did organization effect a more magical change in releasing latent energy. Guided by master hands, electricity leaped into industrial pre-eminence. The value of manufactured appliances multiplied; invention took on added impulse; public confidence in electricity increased. The Company gathered together the ablest minds of the day and placed within their reach unlimited means and the resources of the world as an aid to inventive genius. Written throughout the wonderful development of electrical science and arts is the history of the General Electric Company.

The Development of Electric Light

The Arc Lamp

Many years ago, in experimenting with electric phenomena, luminous effects were noted; but the actual history of electric arc lighting dates back only to 1875. Sir Humphrey Davy, with his chemical battery, in 1800 demonstrated the first crude arc light. But the arc lamp remained a costly laboratory experiment until the development of the dynamo in 1867. The modern period of arc lighting is credited to Z. T. Gramme, a Belgian inventor residing in Paris. His first patent was issued in 1870. In 1876 Jablochkoff, a Russian, perfected a method for controlling the arc, and the new lamps were soon in use in stores and streets. Charles F. Brush and Edmond Weston developed the series arc lighting now in use. The first Brush series arc lamp was erected in Cleveland in 1879. The first central station to operate arc lamps was the California Electric Light Company, in San Francisco in 1879. The arc lamp was the foundation of the electrical industry and the experimental work to sub-divide the arc led to the discovery of the incandescent lamp.

From this humble beginning have been developed the present luminous arc lamps manufactured by the General Electric Company. These are made in two general types, known as the pendant and ornamental types. The former is designed for general street lighting, while the latter is adapted particularly for lighting business streets, or so-called "White Way" lighting.

The Incandescent Lamp

When the commercial world demanded electric lamps similar to the gas lamp then in use, such inventors as Swan, Edison, Brush, Sawyer, Weston and Maxim directed their exclusive efforts to solve the problem. As early as 1841 De Moleyna patented in England an electric lamp of crude form, in which a platinum wire enclosed in an exhausted globe was made incandescent by electricity. A few years later Starr of Cincinnati devised another lamp consisting of thin strips of graphite enclosed in a glass globe. No permanent lamp resulted from this early work and the scheme was declared impractical up to the very day Thomas A. Edison produced the first successful electric lamp.

Thomas A. Edison, a young man who had already shown his wonderful genius by the invention of the quadruplex telegraph, the telephone receiver and the phonograph, began his epoch-making work on the electric lamp in his little laboratory at Menlo Park, N. J., and in the small Edison shops in New York City, nearly forty years ago. In those years of 1878 and 1879 work went on day and night, and the entire field of science and the world at large were ransacked for a suitable filament for the new lamp.

It was the twenty-first day of October, 1879, when Edison announced to the world that the incandescent electric lamp had been found. Bamboo was selected for the tiny hair-like lamp filament and the tropical world was searched for the different kinds of bamboo in order that the best might be chosen. For the next eight years the lamps were made with bamboo filaments, after which a squirted cellulose was used.

During the first ten years of the new lamp, its efficiency was increased to 3.1 watts per candle and a reasonable commercial life obtained. For nearly twenty years there was no improvement in the efficiency of the lamp until the technical staff of the Research Laboratories of the General Electric Company developed the metallized carbon filament of 2.5 watts per candle. This led to the development in Europe of processes for making filaments from several of the rare metals, such as osmium, tantalum and tungsten, and within a few years the Research Laboratories developed ductile drawn tungsten wire, which, with other improvements, revolutionized the lamp industry by increasing the commercial life of the lamp and reducing its consumption to 1.15 watts per candle.

While investigating the causes of discoloration in lamp bulbs, produced by the gradual disintegration of the filament, the Research Laboratories made another important discovery. *By filling the bulb with an inert gas the discoloration was reduced and at the same time it permitted the operation of the filament at higher temperatures.* Contemporaneously, a new method was found for mounting the filament. These improvements increased the efficiency of the lamp to 0.5 watts per candle in the larger sizes and to about 1.00 watts per candle in the smaller sizes.

The introduction and general adoption of the MAZDA lamp has been literally nothing short of a revolution in the art of interior illumination, with a correspondingly tremendous effect on exterior lighting.

The Development of the Central Station Idea

The development of the central station in the past 25 years is one of the many modern miracles that electricity has brought into this busy and progressive world. The history of this wonderful growth is best told in the difference between the 6 kw. generators of the first central station and the mammoth 35,000 kw. machines of today.

The first central station was installed at Menlo Park, N. J., by Thomas A. Edison in the winter of 1880-81 to demonstrate the practicability of his new incandescent electric lamp. At the same time a central station system was started in New York City, the generating station being located near the corner of Fulton and Pearl Streets. The equipments consisted of six direct-connected units, each having a capacity of about seven hundred 16-candle-power lamps. This plant was started on the 5th of September, 1882, with 5,500 lamps connected. While this station was being equipped, a small water power station was built at Appleton, Wis., and placed in operation first. The development and growth of the central station, outside of New York, did not begin until some years later.

Today there are nearly 6,000 central stations in this country alone and the annual business totals many millions of dollars. The engineering talent of the General Electric Company has been devoted to the invention and design of central station and also substation equipment from the very beginning of the central station idea. Even after the invention of generators, motors and lamps, the manner of installation of these machines, methods of control, records of performance and systems of distribution of the current had to be devised and have been perfected constantly by this company. Apparatus of the General Electric Company is now operating in central stations in every section of this country and in almost every country in the world.

Electricity Solves Transportation Problem

Early attempts to use electricity as a motive power resulted in a few scientific toys before 1882. Thomas Davenport, the Vermont blacksmith who invented the electric motor in 1835, constructed a toy car which ran around a circular track. Three years later a Scotch inventor made a small electric locomotive. A number of such locomotives were built during succeeding years until the Berlin exposition in 1879 when Messrs. Siemens and Halske constructed an electric line of about a third of a mile in length. The first regular commercial line in the world was at Lichterfelde, near Berlin, operated in 1880, but was not a success. Edison, Field, Van Depoele, Knight and many others experimented in electric traction at this time.

The first actually successful commercial electric railway, i. e., the first electric operation of the complete street railway lines of a city, was established in 1887 by Frank Sprague of the Sprague Electric Railway & Motor Com-

pany, in Richmond, Va. The road began operation in February, 1888, was essentially the overhead trolley system now used, comprised eleven miles of track, had thirty cars operating in July, 1888, and has been in continuous and successful operation ever since.

The phenomenal development and growth of electric street railway traction has revolutionized not only city, but also suburban and interurban transportation. In 1890 there were not more than 1,000 miles of electric railways in the United States. From this time up to the present, the mileage has steadily increased at the average of about 3,000 miles per year. In the development and improvement of motors and other apparatus essential to electric traction, the General Electric Company has figured with marked prominence.

In 1895 electric railway equipment reached what might be considered a staple basis of design. Fundamental features, such as the enclosed motor, carbon brushes, series drum winding, single reduction gearing, magnetic controller and the under-running trolley had then become established. There were in service at this time approximately 25,000 motor cars equipped with about a half a million horsepower of motors. A great many of the pioneer car motors were too small for the work, because early designers did not appreciate the amount of power required to accelerate a car. In 1895 the average rating of railway car motors was 25 horsepower. Other forms of street railway propulsion gradually disappeared until about 1900 when electric operation was practically supreme. There then existed some 20,000 miles of city electric railways. Principles of equipment design were on a far more scientific and practical basis. From 1900 to 1910 the electric railway extended rapidly to suburban and interurban transportation. Coincident with this development there was a tremendous increase in the size and weight of cars. The average horsepower of railway motors increased from 35 horsepower in 1900 to 65 horsepower in 1910, and large interurban cars were equipped with four motors, while city cars generally were equipped with two.

This increase in power brought about great improvements in controlling apparatus. The General Electric Company developed the multiple unit control for the operation of cars in train on elevated and subway lines, interurban roads and later for regular city surface cars. With the simplification of control were also introduced forced motor ventilation, reduction in the weight of motor equipments and increase in efficiency, improvement in commutation and introduction of commutating poles, perfection of air brake apparatus, introduction of field control, etc.

The necessity for more powerful locomotives for heavy grades, for larger train units and for a safer kind of power for tunnel service became apparent as early as 1895 in the Baltimore tunnel, where steam trains were continually becoming stalled on the grades. Electricity was then making such gigantic strides that the railroad officials appealed to electrical engineers for aid. The result was that the first electric locomotive for railroad service was manufactured by the General Electric Company and was installed on the Baltimore & Ohio. Thus this road, first in steam in 1830, became also first in electricity.

In 1899 the New York Central took up the study of electric traction for its New York terminal, to eliminate the congestion of traffic and remove the smoke nuisance. Nothing was done, however, until 1903, and in three years electric locomotives were hauling trains on this road. These electric locomotives operate at 600 volts, direct current. The General Electric Company built thirty-five in 1906, twelve in 1908 and sixteen in 1913 and 1914. The last six of these engines were at the time the most powerful electric locomotives ever built, and are capable of hauling 1200-ton passenger trains on level tangent track continuously at 60 miles per hour.

During this period electrification has been steadily progressing, until practically all the extensive steam railroad systems in this country and many abroad have tunnels, or terminals, or grades or certain sections of their roads electrically operated. On some railroads electric locomotives are employed exclusively both for freight and passenger service. The use of direct current has predominated in steam railroad electrification, and it soon became evident that the employment of high voltage would effect very decided economies in initial installation and operation.

The first rise to high voltage was from 600 volts to 1,200 volts. Many roads were equipped at this latter voltage, and next 1,500 volt installations were introduced. Then there was a most notable jump to 2,400 volts when the main lines of the Butte, Anaconda & Pacific were electrified in 1913. The General Electric Company built twenty-one electric locomotives and all the substation apparatus and equipment for this road. The next, and the most significant, step in railroad electrification is the extensive equipment now being built for sections of the Chicago, Milwaukee & St. Paul transcontinental railroad by the General Electric Company for operation at 3,000 volts direct current. The plans for electrification contemplate a total main line distance of 440 miles. Twenty-one 260-ton electric locomotives and all substation equipment are being constructed. The locomotives have a continuous rating of 3,000 horsepower and an hourly rating of 3,440 horsepower each, which makes them more powerful than any steam or other electric locomotive ever built. The electric locomotive has clearly outdistanced its steam rival, and it is not too sanguine to predict that the day is drawing near when electricity alone will operate all the railroads in the world.

The Generator

A hundred years ago when Davy and Volta were experimenting with electricity, the current was secured from costly and cumbersome chemical batteries. It was in 1831 that Michael Faraday discovered that electrical current could be generated by moving conductors in a magnetic field so as to cut the lines of magnetic force. A year later H. Pixii invented the split commutator for reversing the current through the armature. Other improvements were made by J. Saxton, E. M. Clark and others. In 1857 E. W. Siemens improved the field magnetic and invented the shuttle armature. The dynamo became a commercial success in 1866-7.

When the General Electric Company came into the field, generators were, comparatively speaking, in their early stages of development and were manufactured entirely in small sizes. At first these machines were all direct current and of bipolar design. As the demand for greater power in single units arose, four, six, eight and a larger number of poles were employed in accordance with speed requirements with the increase in the size of the machine. Simplification of the design, improvements in methods and means of insulation and ventilation and greater efficiency through the introduction of commutating poles for direct current have been notable steps in the development of generators.

Probably the greatest advancement in the generation and use of electric current came with the invention and development of the alternating current machine. With the perfection of transformers and transmission facilities, the use of electricity for light, heat and power purposes then received an impetus that has carried it into almost every industry on earth. To the development of the alternating current generator may be ascribed in no small measure the marvelous industrial growth of this country.

The largest direct current generators ever built, of 5,200 kw. capacity, were manufactured by the General Electric Company for the Southern Aluminum Company, Whitney, N. C. It is also significant that the largest alternating current generators ever built are the product of this Company, forming a part of recently built 35,000 kw. single unit Curtis steam turbo-generators. In the largest hydro-electric power house in the world at Keokuk, Iowa, where 300,000 horsepower will be wrested ultimately from the Mississippi, are at present installed fifteen immense General Electric Company generators operating at the slow speed of 57.7 revolutions per minute and having a normal rating of 10,000 horsepower each. The production of waterwheel driven, alternating current generators has reached units of 17,500 kw., also of General Electric Company manufacture.

The Electric Motor

Thomas Davenport, a poor, self-educated blacksmith of Vermont, constructed the first rotary electric motor in 1834, which embodies many of the first principles of the motors of today. Between the year 1835-60 a number of inventors perfected different types of motors. Jacobi in 1835 placed a motor to run a boat. Henry, Formant, Farmer, Siemens and others built motors. In 1852 Page succeeded in constructing a motor large enough to run a circular saw and a lathe. Davidson in 1842 ran an electric carriage about the streets of Glasgow. A motor of 10 horsepower was built in 1849 at Liverpool. Two important developments were in the inventions of the shuttle armature by Siemens in 1855 and the ring armature by Pacinotte in 1861. The real motor development began after Gramme's dynamos in 1871.

As in the case of the generator, the General Electric Company brought early prototypes of electric motors into their present commercially efficient state, and their development has been practically contemporaneous with that of generators. The successful development of the alternating current motor has likewise been especially advantageous to the advancement of industrial arts through electric drive. Special speed conditions, variable load and intermittent service have been peculiar problems of industrial drive that have been effectively solved through improved design and ingenious automatic controlling devices; and today, the motors manufactured by the General Electric Company range all the way from the smallest fractional horsepower sizes for domestic purposes and for direct drive of fine, delicate machines to the largest induction type motors ever built, 6,000 horsepower, driving immense steel rolls in the mills of the Indiana Steel Company at Gary, Ind.

The Transmission of Electrical Energy

The development of electric transmission was the greatest boon to the industrial world in the history of manufacturing. The invention of the transformer enabled engineers to harness the most distant waterfalls and to bring this cheap energy within the industrial centers to turn the wheels of mills and factories, light the streets, run the street cars and railroads, illuminate buildings, etc.

It was about twenty-two years ago when the first 10,000 volt transmission line in this country was opened in Southern California, transmitting single-phase alternating current from San Antonio Canyon to light Pomona and San Bernadino, 14 and 28 miles away. In all there were forty 6-kw. transformers, the largest of that day, raising the voltage from 1,000 to 10,000 volts. One of the very first water power stations to transmit alternating current was the Gold King mine, at Talluride, Colorado, in 1890.

In 1877 Dr. Wm. Siemens indicated the commercial possibilities of electric transmission. Marcel Duprez, a Frenchman, sent 3 horsepower at 2,000 volts a distance of 24 miles over ordinary telegraph wires. In 1899 M. Hillairet, of Paris, transmitted 250 horsepower ten miles to run a motor in a paper mill. All these first experiments were with direct current. In 1891, 100 horsepower of alternating current was sent 108 miles in Germany with a loss of only 25 per cent.

These few installations immediately attracted the attention of such eminent engineers and inventors as Edison, Tesla, Thomson, Houston, Lord Kelvin, Stanley and others. From the work of these early investigators the perfection of transmission facilities has progressed steadily with the General Electric Company. The most notable transmission installation in history was recently effected with the Company's apparatus. It is known as the "Big Creek" development of the Pacific Light & Power Corporation, Los Angeles, Cal. At present 70,000 kw. are generated from four machines of 17,500 kw. each in two power houses from a combined drop in the stream of 4,000 feet. The current is generated at 6,600 volts and is stepped up by transformers to 150,000 volts for transmission to Los Angeles, 240 miles away. Thus the development of the transformer into the wonderful apparatus of today brings the power of mountain torrents to the heart of the great industrial centers.

Switchboards

Not until the early eighties was the switchboard regarded as a necessary portion of the electrical equipment of a station.

For convenience switches were first mounted on the side walls of the station and as close together as their dimensions would permit. Following this period, switches and instruments were mounted on a wooden background removed from the wall to allow more space for wiring and the connections. This was the first switchboard. The next step was to substitute a wooden construction in the form of a rack or skeleton framework, which had open spaces through which the wires were brought from behind the board to the connected equipment in front.

From this simple beginning, switchboard development by the General Electric Company has passed through many wonderful inventive stages. The switchboard is now one of the most important pieces of apparatus of the industry. It consists of as many panels as necessary, usually of slate to provide safety, and combines a multitude of instruments and devices for controlling, distributing and recording automatically if wished, the flow of electric current to one or a hundred or more circuits or machines in almost any quantity or way desired. Probably the most notable switchboards ever built were recently constructed by the General Electric Company. These are the highly special types of great remote control boards that control and indicate every movement of all the massive lock machinery in the Gatun, Pedro Miguel and Miraflores locks of the Panama Canal.

The Turbo-Generator

The turbine steam engine is fully 2,000 years old. It was described by Hero, of Alexandria, in his "Pneumatica" about the year 120 B. C. Branca, of Italy, used a small steam turbine to run a little drug grinding mill in 1629 A. D. Thus the turbine was the first steam engine, although the last to be developed.

The first commercial turbine was produced in England in 1884. In 1903 Prof. C. G. Curtis, of New York, in conjunction with the General Electric Company, produced the first vertical steam turbine engine. These turbines are principally used to drive electric generators and have been developed by this Company from the small size of 5 kw. to the largest engine in the world, a single horizontal unit of 35,000 kw. capable of delivering some 50,000 horsepower.

The development of the Curtis steam turbo-generator in the short space of twelve years has thus been nothing short of marvelous. The remarkably high efficiency of these units and the exceptional economy of space secured through the principle of their design has revolutionized the production and distribution of energy from steam. At first the Curtis turbo-generator was built in the horizontal type, then the vertical type, and now the design for all sizes has reverted to the original horizontal construction. During this period improvement after improvement has followed both in the mechanical and electrical components of the machines. It would be physically impossible to build reciprocating steam engines in units of the enormous capacity of the large Curtis steam turbo-generators. The great space such engines would occupy and their lower efficiency in comparison with the turbine would render them wholly impractical to use if they could be built. The Curtis turbo-generator of the General Electric Company may be said to be one of the foremost factors in the vast concentrated production of energy from steam and its consequent economical distribution as heat, light and power in the many thousands of cities, towns and rural communities in this country.

Electricity as a Source of Heat

Notwithstanding the ease with which electrical energy can be changed into heat, and this knowledge was patent to the earliest experimenters, it was only a few years ago that electric heating and cooking devices were introduced to the public. Sir Humphrey Davy, a hundred years ago, with his first carbon arc, melted and fused all known substances. Diamonds, quartz, rare metals were easily melted down; carbon boiled quickly away; even the fire bricks of his crude oven were consumed.

The secret of nearly every electric heating or cooking device is a carefully proportioned bit of resistance wire, or stamped resistance metal, imbedded between insulators and usually enclosed within the device itself. In many places where heat is required in manufacturing, electricity is generally used. The most important installations are for electric welding, electric smelting, electric tempering baths, etc. It is also utilized in a thousand other ways. Electricity for domestic cooking has already reached such a high stage of perfection that the electric range can be said to compare favorably with gas or coal ranges. Probably the most popular heating device is the electric iron now in use in millions of homes. Electric heat is also used for culinary purposes in many of the largest restaurants and hotels. In all these fields the General Electric Company has developed efficient devices and apparatus.

Auxiliary Electrical Apparatus

The auxiliary electrical apparatus that has been invented and improved in the works of the General Electric Company may well be said to cover practically the entire field of the application of electric energy. An enumeration of these devices would be legion. Along with the development of important apparatus came also the invention of much special machinery for making it. The distribution of electric current involved the production of hundreds of wiring devices and accessories, plugs, sockets, receptacles, fuses, switches, etc. Then there are measuring, protective and controlling devices and other apparatus, such as ammeters, voltmeters, circuit breakers, voltage regulators, feeder regulators, signal accessories, rheostats, lightning arresters, insulators, rectifiers, controllers, oil switches, dimmers, projectors, motor-generators, synchronous converters, and scores of other apparatus and equipment.

The Future of Electricity

The making of the electrical industry has been so rapid because of the overwhelming magnitude of the potentialities of this most flexible and efficient form of energy, that the skilled scientists and engineers of the General Electric Company have bent every effort in order to keep pace with the constantly growing demands for its application. They are ever reaching out into new and greater spheres of activity for this universal servant of mankind. No one can foretell its marvelous future; yet so extensive even now are the applications of electric energy, we are impressed that electricity, the mysterious force we know of but do not yet know, is coming more and more to do the world's work.

GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK *Advertisement*

more technical periodicals and books, how dynamos, galvanometers, batteries, telescopes, steam engines, lathes, and wireless apparatus are constructed and how they operate.

The late George M. Hopkins, long an editor on the staff of the SCIENTIFIC AMERICAN, designed much of this apparatus himself. What is more, he built every piece with his own hands before publishing its plans and specifications in the SCIENTIFIC AMERICAN. "Experimental Science" was the title under which his lucid articles were afterward collected in a book now in its twenty-seventh edition. It was in truth science of the most practical and instructive kind, and it filled a decided want at a time when manual training schools were practically unknown in this country.

Exposing Swindlers.

As the SCIENTIFIC AMERICAN ministered to the intellectual requirements of a pre-eminently practical nation, so it guarded its financial interests when they involved machinery. Swindling schemes, based on supposedly revolutionary inventions, are encountered with less frequency now than formerly, chiefly because we have a large class of trained technical men to fall back upon for expert advice. Thirty years ago it was otherwise. The late John W. Keeley, of blessed memory, who talked with the glib obscurity of an Indian Swami and was possessed of the audacity of a Cagliostro, was the prince of these swindlers. Year after year, the SCIENTIFIC AMERICAN jeered at his "etheric vapor," his vibrators, his resonators, and the mysterious forces that served to discharge his etheric weapons and to operate his engines. The editor took the trouble to build a duplicate of Keeley's "etheric gun," to prove that it was operated by compressed air. When Keeley died in 1899, still gaining the ears of a rapidly dwindling number, still living on the spoils of the mechanically ignorant and credulous, the SCIENTIFIC AMERICAN made a thorough examination of his laboratory at 1420 North Twentieth Street, Philadelphia. Every piece of flooring was torn up, and every nook and cranny searched. The investigation turned out exactly as the SCIENTIFIC AMERICAN had predicted twenty years previously. Keeley's "etheric vapor" proved to be compressed air.

There were other schemes besides Keeley's—all of them forgotten now, but as alluring to the unwary investor of earlier days as the possibilities of mines which exist only in the imagination of a Wall Street promoter to the simple-minded stock gambler of our own time. In exposing them, the SCIENTIFIC AMERICAN probably saved many a reader from serious financial loss. Among the schemes effectually disposed of were the carbonic acid motor, the gunpowder engine, the chloroform engine, and various perpetual motion contrivances.

The New Home of the Scientific American.

Although it has grown healthily during the seventy years of its existence, the SCIENTIFIC AMERICAN has occupied but five different buildings. The first home of Munn & Co., as we have said, was located in the old Sun Building, which then stood at the southwest corner of Fulton and Nassau streets. There the paper prospered for a number of years until the old quarters were found too small, particularly for the patent soliciting department. New and commodious offices were, therefore, secured in the original New York World Building, at 37 Park Row, at the corner of Beekman Street, to which location the publication was moved in 1859, and this was its home until January 31st, 1882, when the building was completely destroyed by fire. Practically all the valuable records and papers that had been accumulating for years were lost.

The period from 1859 to 1882 had been one of unusual prosperity for the SCIENTIFIC AMERICAN. It had gained readers in every part of the country and in foreign lands, and had won for itself a reputation as an authority on technical matters. No time was lost in securing temporary quarters, and publication was continued without a break from No. 261 Broadway, at the corner of Warren Street. Here the offices were maintained until 1884. In that year the establishment moved to No. 361 Broadway, at the corner of Franklin Street, where two commodious floors were occupied until the present spring.

After thirty years at No. 361 Broadway, it was felt that more modern quarters were needed—quarters that harmonize with the character of the SCIENTIFIC AMERICAN and the patent soliciting of Munn & Co. The Woolworth Building, the tallest and most modern structure of its kind in the world, was selected as the new home of the SCIENTIFIC AMERICAN and of Munn & Co. Two wings of a whole floor now house the staff of the SCIENTIFIC AMERICAN and the Patent Department of Munn & Co. The new home of the SCIENTIFIC AMERICAN and Munn & Co. is not only more commodious than the old, but is well equipped with conveniences of all kinds so that the businesses of publishing an important periodical and soliciting patents can be conducted with even greater efficiency than before.

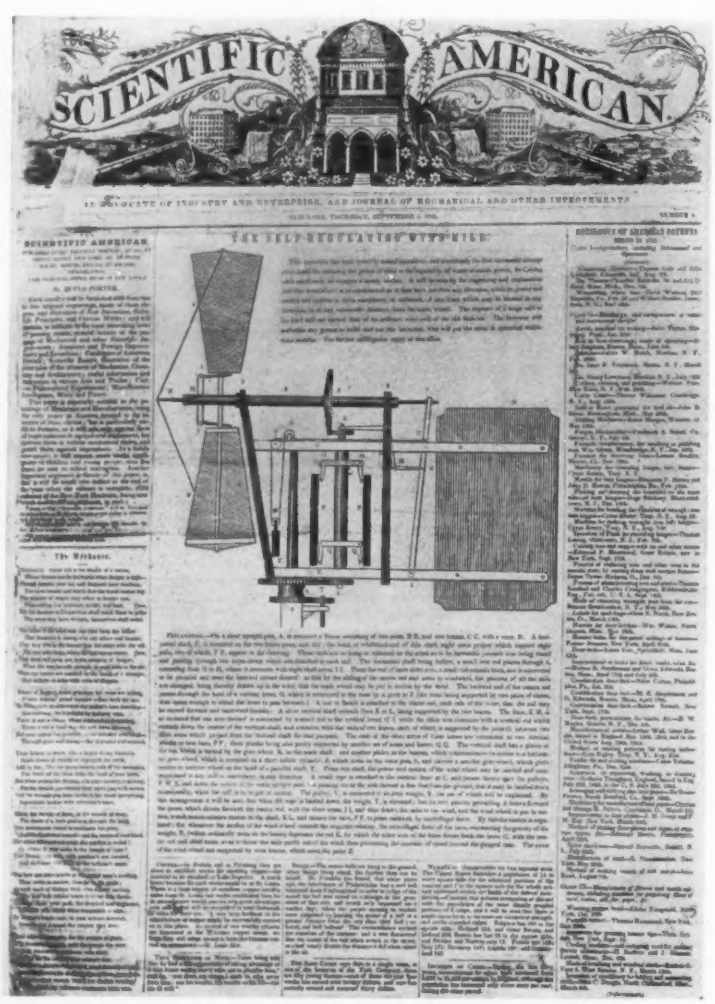
Patent Office Salaries and Expenses Seventy Years Ago

THE seventieth anniversary of the SCIENTIFIC AMERICAN leads us to compare the expenses of the Patent Office seventy years ago with those of last year. The Patent Office salaries in 1845 amounted to $15,545.20 and $4,097.09 was paid to temporary clerks, and the total expense of running the Office, including postage, library, compensation of district judge and $2,392.41 for agricultural statistics, amounted to only $31,172.32; and even with such a small expense the Office earned a net balance of $11,680.49 to be credited to the Patent Fund, which even at that early day was of respectable proportions.

For the year ending December 31st, 1914, the Patent Office salaries amounted to $1,307,092.13 and its total expenditures were $2,000,770.12, with a net surplus for the year of $251,122.70.

In his report dated January, 1846, the then Commissioner of Patents said:

"I will embrace the opportunity to state that I have received from Prof. Morse an interesting account of the different magnetic telegraphs now in operation in Europe made up from materials obtained by personal examination. I am happy to say that Prof. Morse's own brilliant invention by which thought is converged with the rapidity of the lightning flash is eminent over all others of a similar character now in use in Europe."



The Scientific American in 1845.

The Scientific American and the Planing Mill Monopoly

IN the early days of the last century William Woodward, an old carpenter familiarly known as "Uncle Billy" in his home town of Poughkeepsie, N. Y., invented a machine for planing lumber. This machine was provided with rotary cutters and feed roll. A patent was granted to Woodward in 1828, on his planing mill. But being entirely inexperienced in pushing his invention, he could do nothing with it, in face of the strong opposition of carpenters, who saw in the invention nothing but a means of robbing them of their living. Indeed, he had to watch his machine carefully lest it be burned by the hostile journeymen carpenters.

In those days the term of a patent was fourteen years, but by special act of Congress, the term could be extended seven years more if the inventor could show that he had made no adequate profit out of his invention. This William Woodward was obliged to do in 1842. Shortly after, he succeeded in selling his invention to a group of men, each being assigned a certain territory. These men, however, combined their interests and fixed the terms upon which the planing mill could be used. No machines were sold, but in each district a few machines were leased under a contract which bound the lessee to charge a certain fixed price for the work done by his machine. By this means a firm grip upon the lumber industry of this country was obtained. It was impossible for hand labor to compete with the machine, and practically all the business in dressed lumber was thus put under the control of the planing mill trust.

In 1845 the original Woodward patent was surrendered and reissued. In 1849, when it was due to expire, sufficient influence was exerted upon Congress to prolong the patent by another seven years, even though it could hardly be claimed that the patent had not proved a profitable investment. There was a storm of protest all over the country, which mattered little, for the extension had already been granted. However, preparations were made to prevent any further extensions of the patent.

In 1856, which was the year in which the second extension of the patent was due to expire, it was evident that influences were at work to have Congress grant a third extension. At this juncture the SCIENTIFIC AMERICAN took a hand in the fight. It was a young journal at the time, but already it had a long and influential list of subscribers. It began an attack upon the Woodward interests in a series of editorials, and sent out form letters of protest to all its subscribers for their signatures and those of their friends. The patent was due to expire on the 26th of December. Early in December a bill was introduced in Congress for the further extension of the Woodward patent during a term of seven years. The planing mill interests had their lobby workers busily engaged and it was rumored that money was being spent freely. It looked as if nothing could overcome the determined efforts of the Woodward party. It was then that the protest prepared by the SCIENTIFIC AMERICAN was brought in. It was a huge document, "as big as a roll of carpet," they say, containing the signatures of between fourteen and fifteen thousand citizens. It was never read, but it was spread out on the floor and measured with a tape line. The document was found to be fifty feet long and contained two columns of closely written names. That was enough for Congress. The bill died, and the planing mill monopoly came to an abrupt end.

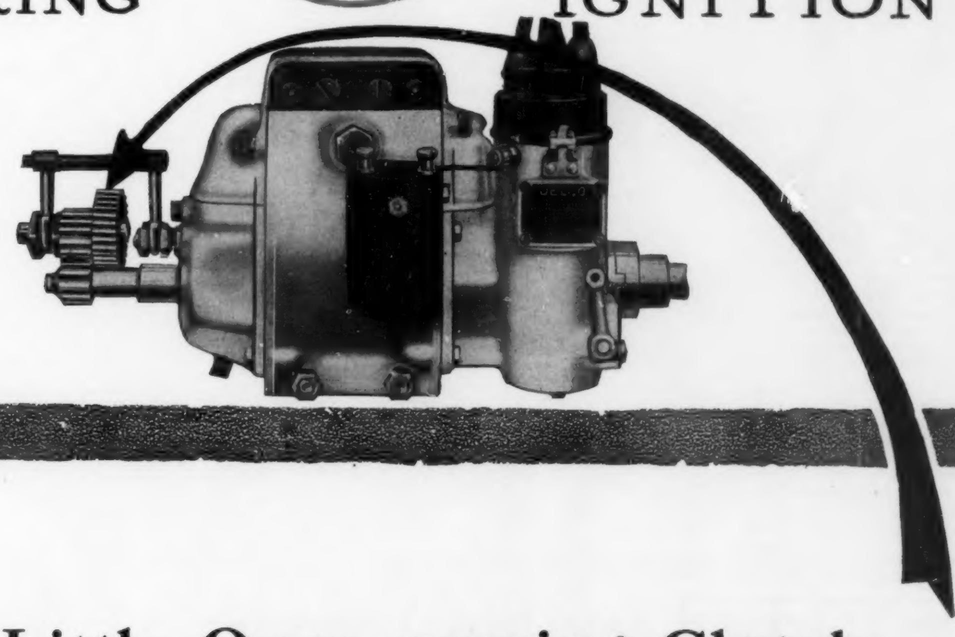
An Intensive Climatological Survey.—Writing on "The Dollars and Cents Value of California Meteorology" in the *University of California Chronicle*, Mr. Ford A. Carpenter, of the Weather Bureau, describes a remarkable instance of a climatological survey in connection with a land development project. The location is a tract of land in southern California, 15 miles long by 5 wide, lying along the sea and rising therefrom in benches and terraces to an altitude of 1,500 feet. Town sites, harbors, hydroaeroplane stations, roads and railways are to be laid out within this tract, and as a guide to their location as well as for the purpose of placing relative values on the parcels of land for country homes and intensive farming, the climatic conditions of the tract are being studied in a most thorough way for a period of one year, dating from last June. Automatic meteorological instruments have been erected throughout the property, the record sheets are corrected and computed, and the great volume of data thus secured will be digested. Thus a detailed knowledge will be obtained of the climatic conditions pertaining to every 10-acre plot in a tract of 16,000 acres. This undertaking is probably without precedent. Of course, in a region of less equable climatic conditions than southern California such a survey would need to be prolonged over a period of many years to give trustworthy results.

DELCO

ELECTRIC CRANKING

THE DAYTON ENGINEERING LABORATORIES Co. DAYTON, OHIO. DELCO LIGHTING IGNITION

LIGHTING IGNITION



This Little Over-running Clutch Protects your Battery

EVERY Motor car driver knows how easy it is to stop the engine and forget to turn off the ignition.

And it is quite obvious that every time this is done a serious drain is placed upon the battery—a drain that will entirely discharge the battery if allowed to continue long enough.

The Delco system protects the driver against his own forgetfulness. This over-running clutch that is used in cranking the engine begins to buzz as soon as the engine stops and keeps right on buzzing until the ignition switch is opened and the battery cut off.

It makes absolutely no sound when the car is in motion—but instantly calls the driver's attention to the necessity of pushing in his switch button when the car stops.

It is only one of a dozen little refinements that are helping to maintain and emphasize Delco leadership.

240,000 Cars are now in Operation Equipped with Delco Cranking, Lighting and Ignition

The Dayton Engineering Laboratories Company, Dayton, Ohio

RECENTLY PATENTED INVENTIONS

These columns are open to all patentees. The notices are inserted by special arrangement with the inventors. Terms on application to the Advertising Department of the SCIENTIFIC AMERICAN.

Electrical Devices.

ELECTRICALLY OPERATED TIME SWITCH.—J. W. PENNEWILL and M. R. BUCHANAN. Address the former, Silver City, New Mex. The switch is especially adapted for lighting circuits whereby the lamps can remain lighted only for predetermined intervals so that there will not be a waste of current by the lights being kept burning when they are not needed, such a switch being especially useful in refrigerating or cold storage rooms where the employees are likely to leave the lamps in circuit negligently when they pass out of the room after having performed the duty that necessitated their entrance.

Of General Interest.

DISPLAY RACK.—O. F. KIME, Crestline, Ohio. The invention relates to racks for displaying articles for sale, such as rugs, and the main object thereof is to so support a plurality of said articles as to be readily displayed individually. It provides a rack from which any desired one of the articles can be easily removed, without disturbing any of the articles thereon.

CORD LEAD.—S. HEYMAN, care of H. Blumgarden, cor. Graham Ave. and Varet St., Brooklyn, N. Y. This improvement relates to guides or leads for cord, cables and the like, and provides an improved construction designed to lead or guide a cable from one side of the wall to the other, so that the wall will normally be closed and solid, but a free passageway will be provided for the cable.

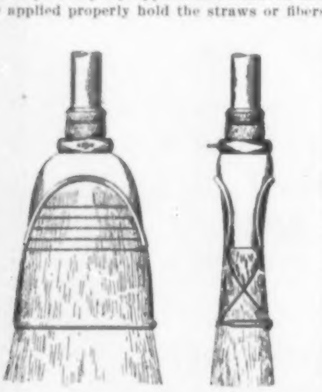
CHUTE.—O. E. WEST, Box 87, Brunswick, Ga. This invention relates to chutes, the more particular purpose being to provide a device suitable for general use and of especial service for depositing loose material, such as phosphate rock, in the hold or other predetermined portion inside of a marine vessel.

SCREENING APPARATUS.—J. J. PHILLIPS, Brookhaven, Miss. This apparatus is more especially designed for screening clay and like material and arranged to separate the finer particles from the coarser ones and deliver the same to different chutes so that the finer particles pass directly to the brick-making machine while the coarser pass to the dry pan to be treated further.

MATCH BOX.—R. DICKSON, 29 Mt. Royal Ave., Hamilton, Ontario, Canada. This invention provides a structure which will vend matches one at a time, and will also automatically strike or ignite the same; provides a vending match box which will disclose to view the matches to be vended, and which is provided with a magazine for reloading the vending part of the box; and provides for vending one match at a time.

Household Utilities.

BROOM PROTECTOR.—J. RABASA, 139 W. 10th St., New York, N. Y. An object in this invention is to provide an improved structure which may be rapidly applied and removed and while applied properly hold the straws or fibers



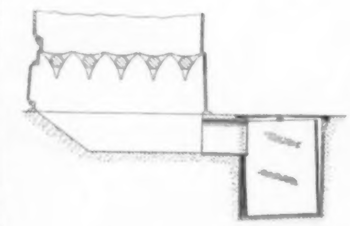
BROOM PROTECTOR.

in position. Another object is to provide a protector which will protect the upper part of the broom and also the broom intermediate the length for preventing the spreading of the broom straws while the broom is in use.

PUMPING MECHANISM FOR VACUUM CLEANERS.—H. ECKEL, 215 North Milton Ave., Whittier, Cal. This invention relates to vacuum cleaners of the type employing a casing and one or more bellows, together with a dirt receptacle, the purpose being to produce a neat and compact vacuum cleaner having a minimum of parts, and all of its parts being readily accessible.

SANITARY SHIELD.—ELEANOR L. BAINBRIDGE-BELL, Mount Bethel, Pa. This invention relates to sanitary shields for seats of water closets, and one of the main objects thereof is to provide such devices in the form of sheets of paper, preferably medicated, having protecting curtains connected therewith when in use, but which present no loose or flapping members before use.

ASH RECEPTACLE FOR FURNACES.—ALBERT B. MEYER, Chicago, Ill. This invention relates to devices for removing ashes from the ash pit of furnaces, without stirring up dust and dirt. In use the ashes which have dropped from the furnace grate-bars to the pit there-

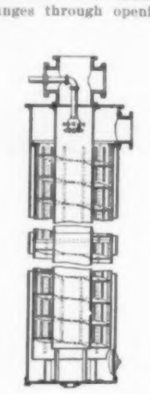


ASH RECEPTACLE FOR FURNACES.

under are pushed through a spout by means of a shovel or the like, into a suitable receptacle which is provided with a removable cover plate, normally in closure position to prevent the escape of dust. After the dust has settled in the receptacle, the latter will be removed after swinging the cover plate open. Thus the ashes can be removed without raising any dust.

Heating and Lighting.

GAS SCRUBBER.—W. M. DERBY, care of Standard Oil Cloth Co., Buchanan, N. Y. The invention provides a gas scrubber having a spiral member for directing the gas in a circular path so that all the impurities and moisture will be directed outwardly to be deflected by flanges through openings in a wall



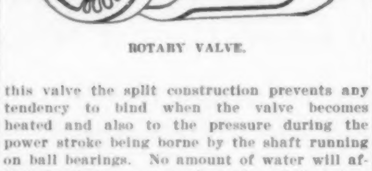
GAS SCRUBBER.

at the outer side of the spiral. It also provides means, among others, for directing gas downwardly and spraying it at the inner side of the spiral to cool and remove some of the impurities, the gas then being permitted to pass upwardly through the spiral.

Machines and Mechanical Devices.

TYPE WRITER.—S. A. THOMPSON, 644 First Ave., New York, N. Y. The invention relates to machines in which a printing structure, preferably in the form of a wheel, is employed, the same being provided with fingers, carrying the printing types on a face thereof. The printing structure is mounted on a frame for movement in its own plane for locating a type at the printing point, and the frame is movable relatively to the platen of the type writer for printing.

ROTARY VALVE.—D. BOWMAN, 435 Fourteenth St., Edmonton, Alberta, Canada. The invention relates to multi-cylinder engines, particularly to those using gas or oil as fuel, and one of the objects thereof is to provide a rotary valve for each of said cylinders having, each, an inlet port and an exhaust passage. In



ROTARY VALVE.

this valve the split construction prevents any tendency to bind when the valve becomes heated and also to the pressure during the power stroke being borne by the shaft running on ball bearings. No amount of water will affect the timing or area of opening of the valve. The operation is noiseless and easy.

TYPE WRITER ATTACHMENT.—G. W. PALMER, 3113 Ricard Bld'g., Seattle, Wash. This invention provides an attachment capable of quick connection to a type writer or detachment therefrom for supporting a roll of gummed or plain paper for receiving addresses, and designed for attachment to envelopes, circulars and the like, or for receiving notes, memoranda or the like, and so arranged that the strip may be withdrawn for use from the roll by the turning of the platen roll.

SOUND REPRODUCING MACHINE.—C. W. WALLER, 2090 Washington Ave., Bronx, N. Y. The invention relates to improvements in sound reproducing machines of either the phonograph of graphophone type, and more particularly to that class of sound reproducing machines in which the sound reproducing and amplifying means are inclosed within a cabinet.

Prime Movers and Their Accessories.

SLIDE VALVE.—J. W. MILLER, P. O. Box 91, Winchester, Ill. In the present patent the invention has reference to slide valves for engines, and the main object thereof is to provide means whereby such valves will automatically find a seat which, at the same time, positions the valve with respect to the ports.

VALVE SPRING COMPRESSOR.—J. J. EAGAN, 90 Monroe St., Brooklyn, N. Y., N. Y. This invention refers to devices for facilitating the removal of valves from the valve casings of internal combustion engines, and is more particularly designed for use in connection with the Ford engine. It provides a valve spring compressor which can be easily and quickly applied, whether to place the valve in position or to remove the same from the valve casing.

Railways and Their Accessories.

RAILROAD SANITARY APPARATUS.—G. W. KELLEY and I. S. KELLEY, care Kelley Bros., Grand Central Terminal, New York, N. Y. This invention provides impounding means for railroad toilets, adapted to be emptied by authorized persons; provides means for heating the impounding receptacle to prevent freezing of the contents thereof; and provides a steam heating equipment for said receptacle, having an automatic drain to prevent the accumulation of water therein.

SAFETY DEVICE FOR RAILROAD TURN TABLES.—J. T. SHERIDAN, Bowling Green, Mo. The improvement provides means which will lock a turntable when it is positioned relatively to a track to receive a locomotive on the track and which will automatically dispose a stop block on one of the track rails when the turntable is unlocked to permit of the rotation of the turntable.

Pertaining to Recreation.

FISHING DEVICE.—D. CONEKIN, care of Pilots Association, Charleston, S. C. The invention provides a construction and arrangement of means whereby fish may be automatically taken from the water and deposited in a cold storage receptacle, without the necessity of manually handling the fish and with a great saving of expense and labor. Mr. Conekin has invented another fishing device, in which he provides an arrangement whereby electric lights may be carried by the net supporting outriggers in such position as to cast their rays diagonally across the course of the vessel so as to concentrate them in advance of the net, in order that fish happening in the zone of illumination may be blinded so as not to notice the approach of net and vessel.

DOLL'S HEAD.—MARY E. RADICK, 26 Oakwood Ave., White Plains, N. Y. This doll has a plurality of faces, each having a different expression with means whereby any one of the faces may be exposed, while the others are covered so that the child can give different facial expressions to its doll, for example, either of happiness or sorrow.

Pertaining to Vehicles.

POWER TRANSMISSION MECHANISM FOR MOTOR VEHICLES.—G. M. STONE, Griswold, Iowa. By this mechanism power transmitted from a suitable drive shaft to the power axle or shaft of a vehicle or machine may be employed so that two sections or power shafts may be driven simultaneously and at equal speeds in one direction, or in opposite directions, or whereby one of the sections may be driven while the other remains stationary, thus permitting the shaft or vehicle to be propelled forwardly or backwardly, or in the event of a vehicle turned at short angles approximately squarely around.

RESILIENT TIRE.—S. B. NEUHAUSEN, care of Alfred Doria, 229 W. 46th St., New York, N. Y. An object of this invention is the provision of a resilient shoe for automobile wheels wherein the shoe is formed with a substantially tubular body divided into sections, and the sections split so as to present resilient side members.

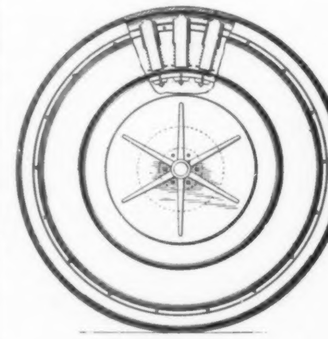
SPEED CHANGING GEAR.—E. M. RAYBURN and A. G. RAYBURN. Address E. S. Rayburn, Sausalito, Cal. This flexible device is for use in transmitting power from the power plant of the vehicle to the wheels, wherein the driven shaft is connected to the countershaft by means of a variable speed connection, and wherein the countershaft is connected to the driving shaft in such manner that the said shafts may be smoothly and gradually connected without any shock or jar.

CRIB ATTACHMENT FOR GO-CARTS.—C. S. HEATH, Montrose, Colo. This improvement provides a crib of a form attachable to and detachable from an ordinary folding go-cart of any approved form. It provides a firm leg support for the front of the crib, together with fastening means for the rear end of the crib, to detachably secure the crib body to the top frame of the cart body, at the rear.

HEADLIGHT CONTROL.—W. C. SYKES, Greensburg, Pa. An object of this invention is to provide means for projecting a light downwardly or upwardly so as to illuminate a rising or descending road in front of the vehicle, whereby the steepness of the road can be easily brought to the view of the driver of the vehicle.

WHEELBARROW.—J. H. ROYALL, Wake Forest, N. C. The purpose here is to provide a device having sides of very light material which can be brought into position or removed therefrom, and which, when removed, are still carried by the bottom portion of the device, so that there is never the necessity of hunting for sides which have been misplaced.

WHEEL.—T. C. BENBOW, Absarokee, Mont. This invention provides a resilient wheel for use with motor vehicles, such as automobiles and the like, wherein cushioning elements are arranged within a tire for cushioning jar and shock, and wherein the tire is provided with a tread member, and wherein all of the cushion-



WHEEL FOR MOTOR VEHICLES.

ing mechanism is housed in such a manner as to prevent the entrance of dust and the like, while at the same time the resiliency of the wheel is not impaired, and the wheel is not increased in size and does not differ greatly from the ordinary wheel.

HYDRAULIC TRANSMISSION.—W. B. PEPPER, Montrose, Colo. In this patent the object of the invention is the provision of a novel differential transmission unit having a hydraulic action and attaining the desired results, including a wide range of gear ratios, both forward or backward, without the use of either spur or bevel gears.

MAXIMUM PRESSURE SAFETY INFLATING TIRE GAGE.—S. P. NOE, 142 Mt. Hernon Way, Ocean Grove, N. J. The primary object of the inventor is to provide a device which will provide a certain and positive means for insuring the exact pressure in an inner tube for a pneumatic tire or the like that such tire is designed to carry, and to automatically indicate at all times the pressure within the tire and especially the maximum pressure which the tire is adapted to withstand.

COLLAPSIBLE CORE.—G. E. HORTON and C. S. WAGNER, 198 South Main St., Akron, Ohio. The collapsible core is for use in the manufacture of rubber tires; and the inventor's object is to provide a core which can be easily and quickly manipulated. This object is attained by providing a core formed of a plurality of sections bound together by means of fixed and expanding rings.

Designs.

DESIGN FOR A VANITY CASE.—E. A. GUTHMAN, 139 W. 19th St., New York, N. Y. This vanity case is oblong in form and comprised of three sections, of which the center one holds a small circular mirror, the whole article having scalloped edges around it and across the tops of its sections.

DESIGN FOR A BUTTON, BADGE, OR SIMILAR ARTICLE.—P. R. JOLLY, 51 Maiden Lane, Raleigh, N. C., and R. L. FOWLER, New York, N. Y. This design is circular in outline and consists of a baby sitting on a floating leaf, holding a lily in its hand, the infant held by a cord grasped by the bill of a tall water bird standing on the edge of a reed bank and dressed in the garb of Uncle Sam.

NOTE.—Copies of any of these patents will be furnished by the SCIENTIFIC AMERICAN for ten cents each. Please state the name of the patentee, title of the invention, and date of this paper.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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Studebaker

SIX $1385

Look for Quality EVERYwhere —not just in "spots"

You can find many cars that excel in this or that detail of construction. One will talk POWER steadily—because it has paid most attention to power—developed that one quality more highly than others. Another, perhaps, will talk of its light weight—because its engineers have devoted especial attention to doing away with useless weight. Others will tell you of this or that BIG excellence. But Studebaker emphasizes no ONE excellence in this Studebaker SIX to the exclusion of all others. For the simple reason that Studebaker has built this Six to be 100 per cent. quality from "stem to stern."

It's the "evenly built" SIX

Straight thro' the car you can go and find QUALITY in every detail. No *one* feature over-developed. But *every* one as highly developed as Studebaker's $45,000,000 resources permit.

And that is why men who have in the past paid high prices for Sixes—twice, thrice the price of this Studebaker SIX—now are buying Studebakers. They find that at $1385, this Studebaker SIX gives all that formerly they paid much higher prices for.

They want BEAUTY—and they find it in this SIX. They find a long and massive car—a car that sits close to the road. With long, unbroken lines sweeping back in graceful curves.

A satiny lustre that STAYS bright

And a finish that few cars at any price can match—a smooth and satiny lustre that STAYS new—because it is worked on thro' 20 operations during the two months the car stays in the paint-rooms.

And not a detail is overlooked to enhance the beauty of the car, either. Handsome CROWN fenders and running-boards free of tires and tool-boxes, hidden handles of the doors—all lend grace to the looks of the car.

They want COMFORT—and they find it in this SIX. They find a big, inviting car—with room enough in the driver's seat for the tallest man to sit in comfort, even thro' long days of touring. Plenty of room in the tonneau, too.

Deep, restful cushions of high-grade leather

And the wide, roomy cushions, so deep and restful, are alluring to the man who has owned the costliest of cars.

The doors, too, are wide and easy to open. The hinges and the catches are cunningly hidden so that no latch lies in ambush to rip even the fluffiest of summer dresses.

But what of POWER? comes the query. And merely a glance at that simple motor suffices to convince any man who knows motors of the silent and flexible power this SIX has.

See how simply and cleanly designed it is—marvelously accessible in its every detail—built to develop power—but ECONOMICAL power that takes you uphill and down, over any roads, always making every drop of gasoline PULL.

Silent and Flexible Power

And then, the simple, RELIABLE-at-any-speed Battery ignition system that Studebaker uses in place of the magneto. Most of the leading cars have discarded the magneto—but Studebaker is especially fortunate in having done so THREE years ago—and in having had THREE extra years' experience of over 100,000 Studebaker owners to work on in the development of this Electric System.

And then, as you study the rest of the car's make-up, that Studebaker FULL-floating Rear Axle, for example, catches the eye of every man who has ever driven a car. Simplicity itself in design, it says at a glance to the man who knows cars—"SAFETY" and "ACCESSIBILITY."

The EASIEST-riding Car you ever sat in

The radius rods and torque arm say that the car rides freely and smoothly on ANY roads. For they take the driving thrusts off the long, flat springs that you find in the rear. Wonderful springs they are, too—a marvel to the man who knows the difficulties of spring designing. For they are the outcome of THREE long years' experiment with designs and steels of a hundred alloys. Three-quarter elliptic, with spring-shackles at both ends to take up end-play, they make the car marvelously EASY-riding.

You find a brake equalizer such as only one of the $5,000 cars uses. Oversize brakes, too, that insure SAFETY. You find a deft balance of chassis that makes the car EASIER-riding, easier-driving—easier on tires, too.

Can you get more—even tho' you pay more?

And so you can go from stem to stern of this Studebaker SIX and find QUALITY—in every little detail. And when you stand it side by side with other cars, even at twice its price, you will have to answer a very decided doubt in your own mind as to whether you CAN get more than $1385 will buy in this Studebaker SIX. See it at your local Studebaker dealer's—and EARLY if you hope for prompt delivery.

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That's our advice on the day this issue of The Scientific American goes to press. With 148-acre plants, the largest in the industry, most of them running overtime, we aren't going to be able to fill anything like the orders we're getting. We've built 25,000 cars during the last six months—the winter months at that—and even then, there's a Shortage of SIXES in sight. Your local Dealer may have a few left—but not for long. Better see him NOW.

Studebaker Prices

Studebaker ROADSTER - - -	$ 985
Studebaker FOUR - - - - -	985
Studebaker SIX, 7-passenger -	1450

F. O. B. Detroit

Prices in Canada

Studebaker ROADSTER - - -	$1250
Studebaker FOUR - - - - -	1250
Studebaker SIX - - - - - -	1750
Studebaker SIX, 7-passenger -	1825

STUDEBAKER — DETROIT

Canadian Plants, Walkerville, Ont.

In 1845 Fingers and Quills Were About the Only Counting Devices

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"LITTLE THINGS THAT COUNT"

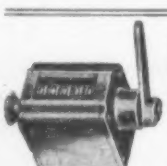
The advantage underlying all Veeder counters is that they enable you to know exactly what automatic machinery and operators are doing. It is this analysis of what is going on (and the resulting improvement) which distinguishes modern business from old-fashioned business. The time is coming when it will be considered absurd to have any considerable manufacturing department which is not equipped with these little automatic counters. There is a Veeder counter for practically every purpose. If you do not see one here that seems to fit your need, or of whose application you are dubious, write us for further particulars. And anyhow we would like to send you our booklet. It is yours free for the asking.

Set Back Revolution Counter

Half Size

Equipped with Lock and Key

This instrument counts one for every complete revolution of the shaft. This counter can be furnished either in the form of direct drive ratchet or locked wheel. Models are supplied with any number of wheels up to ten. It may be set back to zero instantly but only by the possessor of the key in the case of this particular model. The lock and key feature is optional.



Small Set Back Counter

Half Size

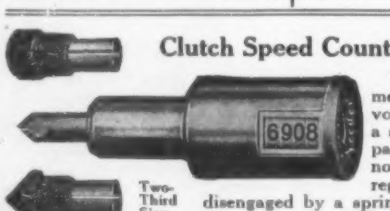
Our Small Set Back Counters are just as high grade as our large counters and are designed for somewhat lighter work and are lower in price. This counter is supplied in either ratchet or revolution form, as desired. Choice is offered of 3, 4 or 5 wheels. Price $4. With lock and keys $5.25.

Rotary Ratchet Counter No. 6

Full Size

In this Ratchet Counter there are no internal stops to regulate the throw of the lever. It will register only in the forward direction and the number of figures registered depends upon the distance the lever is moved. Price $1.00.

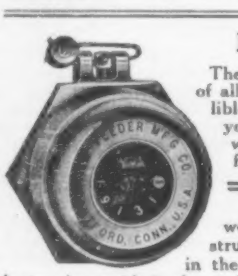
Clutch Speed Counter No. 21



Two-Third Size

This is the best instrument for determining revolutions per minute of a shaft or any revolving part. A stop-watch is not required, since the register is automatically disengaged by a spring clutch the instant pressure is removed. This is the most satisfactory speed counter ever designed. It will not stick or overheat at high speeds. Price $3.00.

HUB ODOMETER



The Hub Odometer is one of the most useful of all Veeder devices. It gives you an infallible record of the distance traveled by your car forward and back. There is no way to beat or deceive it. A great comfort to men who "want to know."

Mechanical engineers know that the word Veeder stands for the best constructed and most accurate counting devices in the world. It is not, however, generally known how wide is the variety of instruments we are prepared to offer for use in almost every line of business. It will pay any business man to write us and find out just what we offer for his individual advantage.

Cyclometers for Bicycles and Motorcycles. Odometers for Automobiles and Horse Drawn Vehicles. Counters for practically every purpose. Tachometers, Tachodometers and Fine Die Castings.

Veeder Mfg. Co.

18 Sargeant St. Hartford, Conn.

Seventy Years of Invention

(Concluded from page 520.)

menting. The present type of automatic bobbin-changing loom was the outgrowth of an invention made by James H. Northrop, who instead of following the old idea of changing the shuttle in order to renew the weft, conceived the idea of changing the bobbin in the shuttle automatically while the loom was in motion. By April, 1890, several looms were constructed on these lines. The basic patent for filling-changing looms was granted on June 23rd, 1891. Before this patent was issued no one had ever automatically placed filling in a shuttle in a shuttle box of a loom and threaded the shuttle automatically. On the same date, Rhoades received a patent for shuttle-changing mechanism, which applied the principle of the weft fork for detection of the absence of the failure of filling and of an ejector to the changing of a shuttle in which the filling was exhausted. These patents constitute the foundation of the monopoly possessed by the Draper Company for automatic filling-changing looms.

An early patent for automatic weft-replenishing looms, especially adapted for multi-colored weaving, was granted to Wyman and Crompton in 1898. These inventors were the first to use a loom containing a series of shuttles under the control of a pattern surface to present at a shed a shuttle having a desired different colored filling and an apparatus by which to provide such shuttles automatically with like filling, thus avoiding the stoppage of a loom when filling is to be supplied to a shuttle; also having suitable devices to move positively the filling feeder having filling of different colors, so that the filling of the desired color may be put in position to be removed from the feeder and put into a shuttle then in place to receive it.

1905-1915

The nearer we come to the present day the more difficult it is to pick out the inventions of importance. It is impossible to tell at the birth of an idea what its future development may be. And so in listing the inventions of 1905 to 1915, we shall undoubtedly leave out many inventions that may prove of highest consequence in years to come, and, on the other hand, we may include some that loom up rather large now, but which when viewed from the proper perspective of time, may prove to be not so important after all.

Many of the recent inventions are referred to in detail in the special articles in this issue, and to avoid repetition they will not be listed here, which will account for the rather meager showing of the following list.

Paper Pulp Improvements.

In the paper pulp industry the past ten years have been marked by important developments: The rate and uniformity of production have been increased especially by the use of tall magazine grinders, introduced from Germany within the past three years. Grinders of the magazine type hold twelve cords of wood, which are sufficient to keep the stone engaged for a twelve-hour grinding period. The supply of stone to the grinder box is regulated automatically by hydraulic presses operating on each side of the stone, so that the grinding operation may be continued during an entire night shift without attention.

In the United States the development of the paper industry to its present proportions has taken place very rapidly. The Fourdrinier parts have been lengthened and widened until to-day paper machines are actually in operation which have a width of 202 inches and are capable of being speeded up to 700 feet a minute, as against 90 inches of width and 200 feet a minute not so many years ago. In Germany, prior to the outbreak of war news-print machines had been contracted for to run at a speed of 1,000 feet a minute, each being equipped with wires of 204¼ inches maximum width. The introduction of scientific methods and management in the paper industry has resulted in reducing the cost of paper notwithstanding the rising prices of raw materials. In 1879 the average price of all paper was $122 per ton, and in 1909 the cost per ton to the consumer was $56.

High-speed Printing.

After Campell, Tucker and Crowell had brought the newspaper printing press to a point were 24,000 to 29,000 copies could be printed an hour, no marked improvement was made until Henry Wise Wood introduced radically new ideas. One of his first presses was installed in the offices of the New York *Herald* this year. Instead of drawing the paper through the press—a proceeding which subjected it to strain and reduced the speed of printing for fear of breakage—Wood carried it along bodily without strain to the printing types. The machine adjusts itself automatically to the peculiarities of the various paper rolls, so that breakages are avoided and the amount of attention required by the press is reduced to a minimum. The paper is handled in streams and assembled in a single stream made up of as many thicknesses as the newspaper to be printed has leaves. This combined stream is then folded, cut and delivered. The rate of printing is 60,000 an hour (eighteen to thirty-two pages.)

Although inventors had given the newspaper office the rapid printing press and type casting and composing machines, stereotyping remained almost at its starting point, one of the few arts still in the realm of hand labor. In 1900 stereotyping was revolutionized by the introduction of Henry Wise Wood's "Autoplate" machine. This consists of a casting mechanism and a series of finishing mechanisms which automatically co-operate in one machine to make casts and finish them. When used to make plates of the conventional half-inch thickness its speed is four finished plates a minute; but when the thickness is but one quarter of an inch eight plates a minute are easily obtained. A single machine does work that could not be so well performed by thirty-five men.

The Gyroscope.

One of the promising developments of the decade, but whose importance it is impossible to gage thus far has been the use of the gyroscope in a great many widely different applications. Mr. Louis Brennan, inventor of the Brennan torpedo, devised a gyroscopic monorail, the car being supported on the rail without any lateral guides, by the action of a pair of oppositely turning gyroscopes. This renewed interest in the previous invention of Schlick, who used a gyroscope to keep a ship from rocking. Dr. H. Anschütz-Kämpfe developed a gyroscopic compass to displace the magnetic compass, and this has been used with considerable success in warships, particularly submarines in which the compass is entirely surrounded by a steel shell that acts as a shield for the magnetic needle and prevents it from being affected by the earth's magnetism. A gyroscopic stabilizer for aeroplanes was developed by Sperry in this country.

Metalizing or Metal Plating.

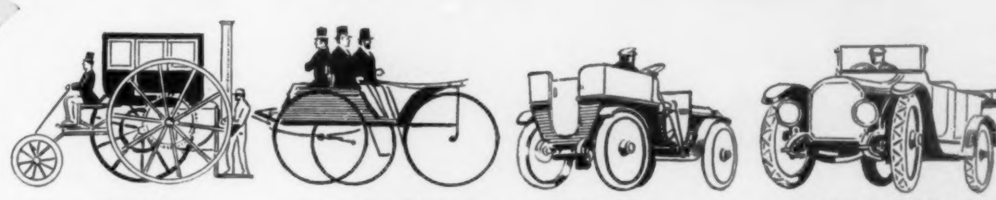
A process of dry galvanizing or "sherardizing" was discovered by Mr. Sherard Cowper-Coles. By this process iron and zinc can be coated with metallic zinc by the simple operation of bedding the piece in zinc dust in a drum and raising the temperature of the zinc dust to 500 or 600 deg. Fahr., which is some 200 degrees below the melting point of zinc. Dr. Schoop of Zürich invented a method of coating objects with metal in which the metal in pulverized state was projected against the object by a jet of high-pressure steam. The object is thus bombarded with a hail of fine metallic particles, which are liquefied by the energy of the impact, and thus soldered one to another.

In 1907 E. G. Acheson discovered a method of producing deflocculated graphite.

Mechanical Engineering.

There were many improvements in mechanical engineering aside from those listed in our article on machine tools. Mr. H. A. Humphrey, a well-known English engineer, invented an internal combustion water pump. In this pump there are no moving parts except the mushroom valves. The explosive mixture of gas and air is ignited in the engine in contact with one

THE FOUR GREAT EPOCHS
IN THE HISTORY OF TIRES



THE EVOLUTION OF THE WHEEL SHOE exhibits four definite phases: *Metal, Solid Rubber, Pneumatic and Puncture-Proof Pneumatic.*

The history of the first three is universally known. The fourth, and greatest development, the production of the LEE PUNCTURE-PROOF PNEUMATIC TIRE, marks a gigantic forward stride into the future of motoring. It signifies the definite passing of ROAD TROUBLE while still preserving the inherent COMFORT advantages of the pneumatic principle.

Furthermore, the elimination of puncture and blow-out naturally tends to increase the MILEAGE of the tire. Still further equipped to resist road friction is the LEE tire by the use of "vanadium" treated rubber. The effect of this exclusive LEE process is to toughen the rubber while at the same time toning and bracing up its natural resilience.

Intensive HAND BUILDING with costly materials is yet another contributory cause to the great LEE effect—MORE MILEAGE. LEE tire construction is fully described in our free booklet.

New million-dollar LEE factory is now running day and night. Sales of LEE Tires have increased over 600 per cent. in the past two years.

NOTE—The LEE Tire is the only pneumatic tire carrying a definite written guarantee of immunity from puncture under penalty of a *cash refund.*

WRITE FOR BOOKLET "17"

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Manufacturers of Rubber Goods Since 1883

CONSHOHOCKEN. PENNA.

Look up "Lee Tires" in your Telephone Directory. Distributors in all principal cities

PUNCTURE PROOF MILEAGE FIRST GUARANTEED LEE PNEUMATIC TIRES

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LEE *Tires*

PNEUMATIC NON-SKID PUNCTURE-PROOF

MAGIC, STAGE ILLUSIONS AND SCIENTIFIC DIVERSIONS, INCLUDING TRICK PHOTOGRAPHY

Compiled and edited by Albert A. Hopkins. With an introduction by Henry Ridgely Evans. 7x10 inches. Cloth. 556 pages. 400 illustrations. $2.50

This very interesting volume is acknowledged to be the standard work on magic. It appeals to the professional and amateur alike. The illusions are all explained in detail, showing exactly how the tricks are performed.

MUNN & CO., Inc., Publishers, Woolworth Building, New York City

end of a column of water which fulfills the dual function of piston and flywheel and moves so as to draw in a fresh combustible charge, to compress this charge previous to explosion, to permit expansion to be carried on to atmospheric pressure, and finally to exhaust the products of combustion. All these movements are brought about and controlled by changes in the momentum which occur naturally in the column of water itself.

Nikola Tesla invented a steam turbine, which depends for its operation on the viscosity of steam, acting upon a series of flat metal disks narrowly spaced apart.

Charles M. Manly, who first sprang into prominence in connection with his work on the Langley aeroplane, developed a hydraulic drive system that is a hydraulic means of controlling the speed of a motor vehicle. A number of similar variable speed gears were developed, one of them being used with great success for elevating or "pointing" the guns of battleships.

Mr. David Roberts invented the caterpillar tractor which could haul heavy guns or other trailers over rough country. The creeping action of the caterpillar tractor enables it to go over country that is cut up by gullies and over sandy or marshy ground with equal facility.

The decade was particularly marked for developments in illumination, but this subject is fully covered in a special article.

In 1906 Hans Kuzel succeeded in making filaments from the colloids of heavy refractory metals such as tungsten, vanadium, etc. The filaments thus obtained when heated pass over to the metallic state and form very thin homogeneous threads of pure metal. Efficiencies of one watt were obtained.

The rise of the moving picture industry made it important to obtain a safe film. In 1907 A. Eichengrün conducted experiments with Becker and Guntrum, which yielded acetyl-cellulose, known better by the trade name of cellite. Cellite is not generally used as a material for photographic films, but rather as a transparent substitute for celluloid for other industrial purposes.

The commercial development of the phonograph in the past ten years has been almost as remarkable as that of the moving picture industry.

Early in the decade Parsons of turbine fame brought out his "auxetophone," a device for augmenting talking machine sound reproduction by the use of compressed air, the air being admitted through a valve controlled by the needle, and hence taking the place of the reproducing diaphragm.

In this decade, Thomas A. Edison completed his storage battery in which nickel hydrate forms the active material of the positive plate, and iron oxide of the negative plate, while the electrolyte consists of a solution of pure potassium hydrate (caustic potash) in distilled water.

Fournier d'Albe invented an apparatus known as the "optophone," which renders light audible. This effect is accomplished by the use of selenium cells in an electric circuit, containing a telephone. By its use a person totally blind may be able to locate a window or open bright light, and to discover readily the shadows of objects passing between him and the light.

The Rise of the Automobile

(Concluded from page 522.)

everything before them. In the rear of the crowd of contestants was Frank Duryea with his American machine. No one had any idea that it would figure prominently in the race. For a long time Frank Duryea was retarded by having to thread his way through the slower machines. One fifth of the distance had been traversed before he cleared the crowd. Then he put on full speed. One after the other he passed the fast foreign cars, and when he reached Brighton he sat down and waited nearly an hour for his nearest competitor to come up. America led the world! But, as Mr. Charles E. Duryea has tersely put it, "Americans were not ready for the automobile. Oats too cheap."

We must turn back now for a moment and look into the early history of the electric vehicle. It antedates the gasoline vehicle, for in 1882 we find, in Boston, an electric "brake" with a capacity for eight passengers. This ran at a maximum of 16 miles per hour and at half that speed could make 40 to 50 miles on a single charge of the battery. In 1888 P. W. Pratt was running an electric runabout on the streets of Boston. The idea of an electically propelled vehicle occurred to inventors long before this, but it was not until about that time that the storage battery had developed to an extent that made it available for pleasure purposes. In 1896 an automobile race was held at the State Fair at Providence, R. I. A Duryea gasoline car maintained the lead, but an electric car built by A. L. Riker followed it closely and was beaten out for second place at the finish by another electric car entered by the Electric Carriage and Motor Company. The next year the Pope Manufacturing Company built a two-seated phaeton, driven by electricity, and in 1898 the manufacture of electric vehicles had assumed such proportions as to make a very creditable showing at the Electrical Show held in Madison Square Garden, New York.

Returning again to the gasoline vehicle, we find Alexander Winton a most active promoter of public interest in the automobile. As early as 1897 he started out on a long-distance tour, attempting to run from Cleveland to New York city. The difficulties of such a trip can only be realized when we consider that the roads in those days were far worse than they are now and the motorcar was by no means a robust machine. It took Winton from June 28th to August 27th to complete the trip. In 1901 Winton tried another very ambitious tour, this time a transcontinental tour. After encountering almost insuperable difficulties, his tour finally ended in the sands of the great desert through which he found it impossible to make his way. In 1903 Winton succeeded in driving across the continent. Two other machines also made the trip, namely, a Packard and an Oldsmobile. The first beginning of automobile manufacture is claimed by Winton, who in 1898 built and sold four motorcars.

The first automobile show in New York was held in 1899. This was really a bicycle show, in which automobiles were included as a prominent feature. The next year the automobile had a show all to itself, and among the features of domestic manufacture were many steam machines and several electrics.

Track racing suddenly became very popular. A notable contest was held at the mile track at Guttenberg, N. J., in 1900, where races were held between gasoline, electric, and steam vehicles. One of our photographs shows the start of a five-mile race between two Panhard and Levassor machines, which was won by A. C. Bostwick in the remarkable time of 7 minutes and 43⅕ seconds, a speed of close to 38 miles per hour. In the ten-mile championship race the same two cars raced, but this time they had a serious competitor in an electric racing car built by A. L. Riker. In these days we are not accustomed to class electrics as racing automobiles, but in that race the Riker machine romped away from the others and led them by many yards at the first mile, when unfortunately, a short-circuit disabled the batteries and put the machine out of the running. Bostwick again won the race. His time was 15 minutes and 9⅘ seconds, a speed of between 39 and 40 miles per hour. It is interesting to note that, despite his early successes, Mr. Riker abandoned the electric and became chief engineer of the Locomobile Company, which originally built steam cars and finally abandoned steam for gasoline.

An omnibus provided with gasoline electric drive was exhibited in 1902. In the Automobile Show of 1903 the air-cooled four-cylinder Franklin was a prominent feature. Public demand for a light, inexpensive car was reflected in the motor-driven buckboard. At the show in Paris that year the beehive radiator made its appearance, also magneto ignition.

In 1904 the American automobile had developed so far that the SCIENTIFIC

A Helping Hand For Every Motorist

This Is To Be Taken Literally And Interests Every Car Owner!

SO FAR as we can, through our Service System, we will eliminate for *any* car owner all inconveniences in the use of tires.

If you use tires other than Fisk, we particularly invite you to stop in at one of our Branches the next time your tires need attention and thereby inform yourself as to the *substantial* qualities of Fisk Service. To present Fisk Users we would say that the privileges enjoyed at your local Fisk Branch are to be found in every city where we are located.

The Secret of the Success of the Fisk Service Policy is its uniformity. The Service is organized. There is nothing like it in the tire industry. We are building our business on an Established Reputation for Good Tires and for Courtesy and a Personal Interest in the requirements of *all* tire users.

Tourists should send for a list of Fisk Branch Addresses and Plan to take advantage of our Service even though they may not use Fisk Tires.

Every car owner, regardless of what tire he may use, is *welcome* in any Fisk Branch. He will find there a spirit of accommodation which will add materially to his pleasure and convenience when his tires are in need of attention of any kind.

Time to Re-tire? (Buy Fisk)

Fisk Tires Are An Extraordinary Buy

Prices are Low. There never was a time when Fisk Tires were better quality or gave more universal satisfaction. This statement can be easily verified by inquiry among Fisk Tire users.

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You Can Buy Fisk Tires From ALL Dealers—Fisk Branches in ALL Principal Cities

Easy access to the front seats from the back is afforded by space between two front seats, making it possible to reach the seat beside the driver without going around the car

Pierce-Arrow

AMERICAN felt justified in declaring that "we have caught up with France, or at any rate, are close to her heels." The Automobile Show that year was very elaborate. The honeycomb radiator had pretty well disposed of the finned tube and was now well established. More attention was paid to automobile tops which would render the cars serviceable in bad weather. The motor was universally placed in front, where it could get air. The air-cooled motor with a fan proved a success. The transmission and rear axles were provided with ball bearings. The mechanism was provided with mechanical lubrication. Carbureters were rendered automatic. The use of the magneto was on the increase, although most of the cars still used dry batteries. Wheel steering became almost universal. Several two-cycle three-cylinder cars appeared. Wood was replacing wire for wheel spokes. Altogether the cars were beginning to approach present standards.

In 1905 people began to realize that they need not store their cars away for the winter, but could use them in heavy snows. The four-cylinder car was well established, and bevel drive displaced the chain almost entirely. The old bicycle wheel tubing disappeared and special girder construction was used in the framework of the chassis. Special grades of steel were introduced. The coach builders became active in improving the design of the car bodies. The jump spark was used almost entirely and the sliding transmission was extensively employed. In 1906 the multiple disk clutch came into prominence, and roller bearings on the rear axles began to be used. A great deal of attention was then paid to shock absorbers and rebound checking devices. The machines were provided with expanding foot-brakes and emergency band-brakes. In 1907 the six-cylinder engine began to appear. Low-tension ignition and also the chain drive were fast dying.

For the next few years there were no startling changes in the automobile, but the body design was greatly improved. The low-priced car made its appearance in 1909, and in 1910 we have the bloc cylinder casting and a common use of left-hand drive. The next year the Knight silent engine, an American invention, which had been taken abroad a few years before because it found little encouragement here, was brought back again from England, where it had met with great favor, and was introduced in American cars. This focused attention upon noise in the common engine, and means were used for quieting even the poppet type of engine.

By 1912 the fuel problem had become so serious owing to the introduction of inferior grades of gasoline to meet the enormous demands of motor users, that mechanical means of starting the engine became absolutely imperative. Suddenly a great many self-starters appeared—some electric, some pneumatic, some operated by an explosive charge, and some by a mechanical spring. The following two years were marked by an increasing use of electricity in gasoline-driven machines, for starting engines, shifting gears, operating horns, lighting the car, and so forth. An attempt was made to introduce the cycle-car into this country, but so far the American public has not taken very kindly to this type of machine.

This brings us down to the present year, in which the chief development is the multi-cylinder engine. The Cadillac Motor Car Company started the movement last fall with an eight-cylinder V-type engine, which is proving so popular that a number of other manufacturers have introduced the eight-cylinder engine or are planning to do so in the immediate future; and now, just as we are going to press, comes the announcement of the Packard Motor Car Company of a twelve-cylinder car or twin six.

Such, in brief, is the history of one of the most remarkable industrial developments the world has ever seen, an industry which in less than twenty years has grown to be one of the most important in the country. Its influence has been felt in a score of other industries. The pres-

"On Time as planned"

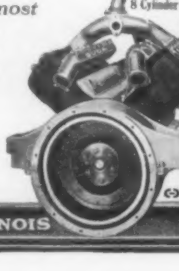
You'll be there if a BUDA motor drives your car.

Whether you allow yourself time a-plenty, or, in a tight pinch, must "make it" in a hurry.

To have a good motor is to be able to forget it. Will you meet that appointment or catch that train? No doubt disturbs you if you drive a BUDA MOTOR. Our *thirty-four years* of striving for the best are behind your peace of mind.

Say, "Has it a BUDA MOTOR?" to the salesman when you buy your car (or truck).

TWICE AS MANY BUDAS THIS YEAR AS LAST proves that our most telling advertisement is the satisfaction of the user. In April, 1915, we sold TWO AND ONE-HALF TIMES as many Buda Motors to twice as many car and truck builders as in April, 1914.



THE BUDA COMPANY, HARVEY (CHICAGO) ILLINOIS

Clamp an EVINRUDE to the stern of any row-boat and you have a speedy motorboat.

THINK of it, you people who love the great outdoors! This wonderful little marine motor enables you to instantly convert any kind of craft—rowboat, sailboat, houseboat or canoe—into a power boat. It drives an ordinary rowboat 7 to 8 miles an hour—a canoe 10 to 12 miles—and runs four hours on less than a gallon of gasoline.

So light that it can be carried with you anywhere. So strong that it is practically unbreakable. So simple that women and children find no difficulty in operating it the first time they try.

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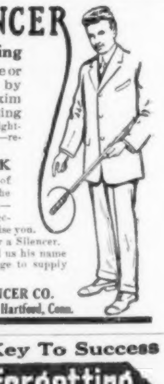
WRITE FOR FREE BOOK

Filled with interesting experiences of sportsmen with the Maxim Silencer—stories of actual records that will surprise you. Ask your dealer for a Silencer. If he has none, tell us his name and we will arrange to supply you.



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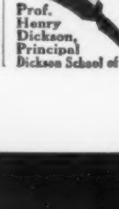
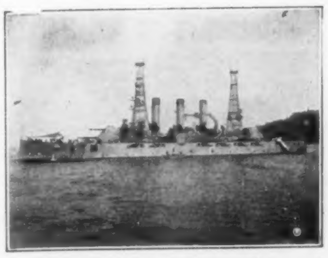


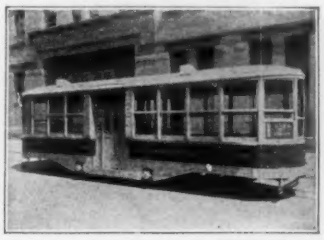
Prof. Henry Dickson, Principal
Dickson School of Memory, 700 Hearst Bldg., Chicago, Ill.

The Wide Use of the Storage Battery

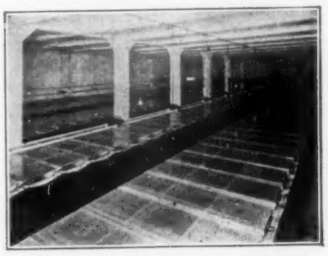
A Story of Unusual Achievement

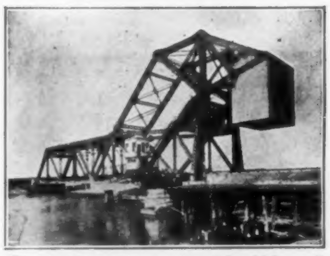

The "Exide" Battery is very widely used both on sea and land for firing large guns.

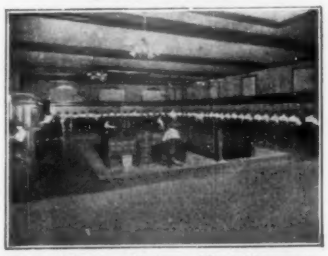

Over 250,000 automobiles are equipped with the "Exide" Battery for starting, lighting and ignition.

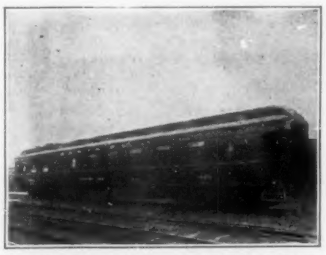

174 of the storage battery street cars in New York City are operated by "Hycap-Exide" Batteries.


A large majority of the Submarines in the U. S. Navy use "Exide" Batteries for their operation when submerged.


"Exide" Stand-By Batteries are used by the large Electric Lighting and Power Companies to assure their customers of uninterrupted service.


The "Chloride Accumulator" is widely used in connection with electrically operated draw-bridges.


The Bell, Western Union and Postal Companies depend upon the "Chloride Accumulator" for telephone and telegraph service.


The "Chloride Accumulator" and the "Tudor Accumulator" are very widely used for car lighting.

DID YOU SAY you were not interested in storage batteries? Do you realize that not a day passes that a storage battery is not called upon to do some work for you? Look at the illustrations on this page. Did you know that storage batteries were a vital factor in all these applications of electricity?

How much use could be made of water if there were no tanks, pails, buckets, etc., to hold it? A storage battery is to electricity what a receptacle is to water.

In this country "storage battery" and "The Electric Storage Battery Company" are inseparably associated. You can't think of one without thinking of the other, because for 27 years this company has produced by far the greatest part of all the storage batteries manufactured in this country.

Just consider this thought. If all the storage batteries made by The Electric Storage Battery Company were suddenly thrown out of service this whole country would be badly crippled. Think of conditions with the millions of Bell telephones out of service. Think of the electric lighting companies in New York, Chicago, Philadelphia, Boston and other large cities without a reserve supply of electricity in cases of emergency. Think of many of the railroads without signal apparatus with which to operate their trains. Think of submarines in the United States Navy without batteries for their operation when submerged. Think of thousands of electric delivery wagons and trucks suddenly made useless. Think of hundreds of thousands of automobiles without batteries for starting, lighting or ignition.

And again, don't get the idea that a storage battery is merely a wood or rubber receptacle containing plates of lead immersed in dilute sulphuric acid.

The big jobs and the imporant ones that storage batteries are doing every hour of the day prove that storage battery design and manufacture is of necessity a highly specialized and developed art. Storage batteries are and have been a most important factor in the growth and development of the electrical industry.

This Company, organized in 1888, is the oldest, the largest and the most experienced storage battery manufacturer in this country. The trade-marked names "Exide" and "Chloride Accumulator" are without doubt the most valuable storage battery trade marks in the country.

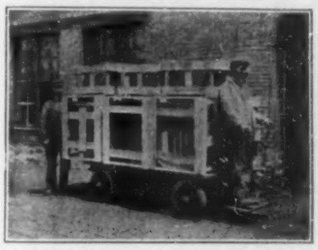
Electrical engineers throughout the country know from long experience that these names stand for scientific design and the highest quality of material.

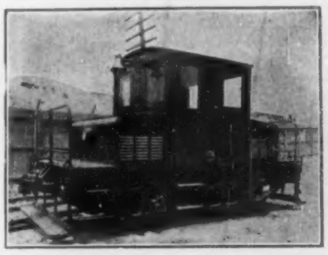
Although the demands for new types of storage batteries have developed so rapidly, yet this Company has always thoroughly tested under actual service conditions each new design of its batteries before allowing it to be put on the market. It has not experimented on its customers. The reputation of the Company has been very carefully built up and maintained from year to year.

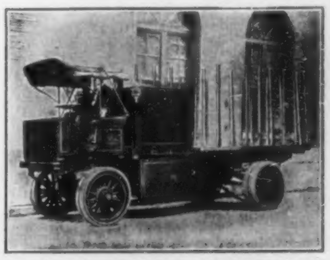
And beside designing and manufacturing storage batteries which have given the Company the leading position in the industry, it has also built up a large service organization so as to most efficiently serve its customers in all parts of the country. This organization includes 15 Sales Offices, 13 Battery Depots, Branch Construction and Operating Departments and over 1000 Distributors. No battery user is far from a reliable source of information.

If you are interested in storage batteries, whether a small battery for your motor car or a large battery for your local electric lighting company, you can with the utmost confidence take up the matter with this Company.

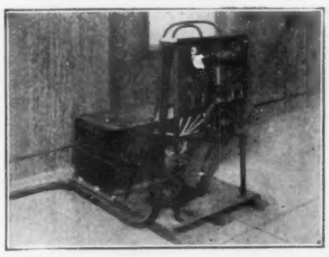
Engineering co-operation, battery instructions, descriptive literature covering batteries for any particular service—all are at your disposal. Write our office nearest you.

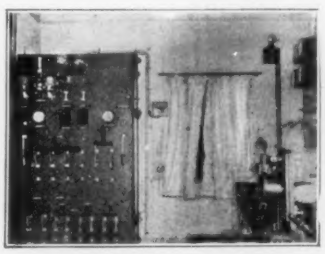

Industrial trucks, operated by "Ironclad-Exide" Batteries are found to be efficient and economical.

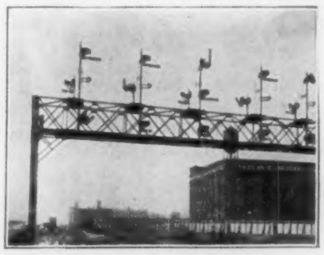

"Exide" and "Ironclad-Exide" Batteries are very widely used in industrial and mine locomotives.

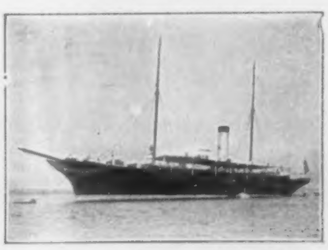

The four famous "Exide" Batteries have for years been used in a large majority of all electric vehicles manufactured.


The dependability of the "Exide" Battery is strongly evidenced by its use in aeroplanes.


The "Hyray-Exide" Battery has made it possible for every farm to have its own electric lighting plant.


The "Chloride Accumulator" and the "Exide" Battery have been made standard for wireless service.


The "Chloride Accumulator" "Tudor Accumulator" and "Exide" Battery give the reliable source of energy necessary for railway interlocking switch and signal work.


Hundreds of yachts are equipped with the "Chloride Accumulator" or "Exide" Battery for electric lighting service.

THE ELECTRIC STORAGE BATTERY CO.

PHILADELPHIA, PA.
1888-1915

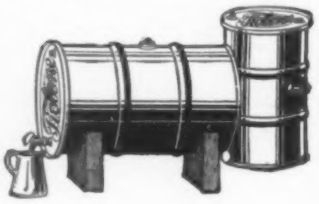
New York Boston Chicago Washington Denver San Francisco Seattle St. Louis
Cleveland Atlanta Pittsburgh Detroit Rochester Los Angeles Toronto

When ordering, say—Medium—Heavy—or Ford Special—That's all you have to know about

Tiolene

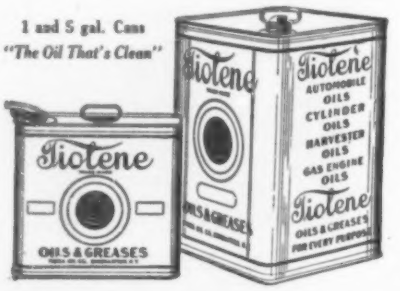
"The Oil That's Clean"

It's refined from Pure Pennsylvania Crude to properly lubricate an automobile engine—it does it—and renders the engine 100% efficient. What more can an oil do? It has proved itself, thousands of users attest its superiority, and one trial will convince the most skeptical. Ask your dealer. If he does not handle it, write us. We will either sell you direct or put you in touch with a dealer who does sell "Tiolene." At least send for the booklet—"The Oil That's Clean."—It's not large, but it's interesting. Send now.

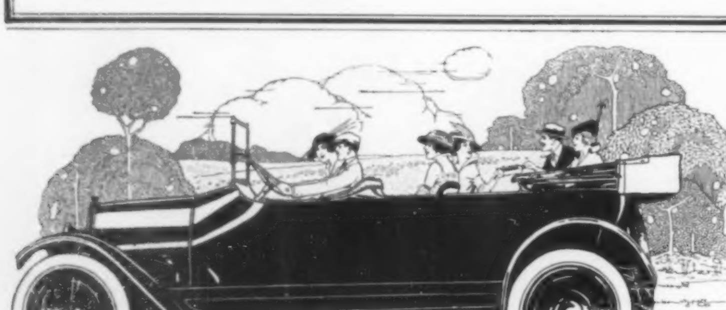


TIONA OIL COMPANY
BINGHAMTON NEW YORK
A limited territory open to jobbers and dealers

1 and 5 gal. Cans
"The Oil That's Clean"



Tiolene in Steel Drums containing 33 and 54 gallons for use in the private garage. The cleanest, cheapest, handiest way to handle your oil. Invisible faucet for drawing off the oil as needed. Convenient in your motor boat house. Write to-day for prices. Look for the "Bull's Eye" Sign along the road.



It took twelve years to build this Car

The building of this car with 1200 fewer parts, has been supervised by Capt. William Mitchell Lewis, pioneer in the automobile field, collaborating with M. Rene Petard, celebrated French engineer. Into the

LEWIS "VI"

Monarch of the Sixes

has been built the experience-bought knowledge of twelve years of automobile construction. Read the specifications and see how much value can be built into an automobile to sell at $1600.

Gear Shifting by Electricity

When your Lewis Six is equipped with the Magnetic Gear Shift, you can drive it as easily as an electric coupe; no stripping or clashing of gears. The Magnetic Gear Shift is manufactured by the Cutler-Hammer Mfg. Company, Milwaukee. Optional equipment at $150.00 extra.

SPECIFICATIONS

135-in. wheel base and 56-in. underslung rear springs, easy riding and comfort on country roads. Six-cylinder motor develops more horsepower to the cubic inch than any other automobile engine on the market. Reserve gasoline supply—Stewart vacuum feed—Remy starter—Stromberg new type carburetor—Stanweld rims—Power tire pump—One-man silk mohair top—Tread 56 inches, tires 36 x 4—Crown fenders and integral cast aluminum windshield bracket and instrument board—a car of "class" from radiator to tail-light.

Let us have your name and address and we will tell you where you can see and ride in a Lewis "VI," also send you the Lewis catalog.

L. P. C. Motor Co., 75 LEWIS STREET Racine, Wis.

ent high development of American machine tools is directly traceable to the automobile. American automobiles invaded European markets even in time of peace and proved to be a serious competitor, especially the lower-priced cars, and now our motor trucks are pouring into war-torn Europe.

A report just issued by the United States Department of Agriculture on the motor vehicle registrations and revenues for 1914, shows that we have 1,660,984 automobiles in service and 44,355 motor trucks. There are 21,255 manufacturers' and dealers' licenses and 427,179 owners' and chauffeurs' licenses.

Transportation on Land and Sea

(Concluded from page 526.)

Considerably over a billion passengers have been carried on this system, through a continuous stretch of years, without the loss of a single life.

Development of the Steam and the Electric Locomotive.

The purpose of the present article is to trace the principal improvements in the steam locomotive during the past seventy years, and follow this with a brief account of what has been done in applying electrification to steam railroads.

Beginning with the year 1845, we note that the locomotive engine had then reached a high degree of efficiency, but was still far from being an economical power plant. We shall, therefore, find that during the period under notice the efforts of engineers were to make the locomotive more efficient by increasing its hauling capacity and reducing the cost of fuel and maintenance. Progress has thus been attained by studying the details of feed-water heating, more or less perfect combustion, variable steam cut-off, compounding, superheating, and mechanical stoking; for, as life is made up of details, so is the locomotive engine.

Fig. 1 shows a typical locomotive of seventy years ago. It was a wood-burning Rogers engine weighing about 18 tons and was built for the Morris & Essex Railroad, now a part of the Lackawanna Railroad system. It had a peculiar double valve gear with independent cut-off, by which the lap of the valves could be varied at will, with the object of economizing steam; but the design was soon abandoned and the Stephenson link motion was adopted. For about fifty years this valve gear was in general use, but the increasing size of the engines involved a proportionate increase in the weight of the double eccentrics and heavy links, so that at high speeds the friction and resistance were enormous. A further objection was that the link connecting the two eccentrics, moving through wide angles, caused the block to slip in the link, producing distorted and lost motions. For these and other reasons, it has ceased to become a desirable valve gear.

About fifteen years ago the Walschaerts gear came into use in the United States. This motion, while retaining the link, dispensed with one eccentric, and could be placed outside the frames, giving easy access to the parts. Also, the link being pivoted to a fixed center, there is not so much slip and lost motion as in the Stephenson gear. An exhaustive article on this valve motion will be found in the Scientific American Supplement of March 27th, 1909.

In recent years some improved valve gears have been introduced to still further remedy the evils of radial motion. Two examples are illustrated herewith. Fig. 5 shows the Baker valve motion, which dispenses with links and sliding blocks, and substitutes a bell crank lever, a radius bar and a yoke. The movement is derived from the cross-head and the eccentric crank. The cross-head moves the valve the amount of the lap and lead each way, and the eccentric crank gives the remainder of the movement. The operation gives a quick opening of the port by the valve, and an increased pre-admission as the cut-off is shortened—a great advantage in high speeds.

Fig. 4 illustrates the Southern locomotive valve gear. In this design there is a link, but it is bolted rigidly to the engine frame and is stationary. There is thus no slip of the block, as it only moves in the link when the reversing lever is shifted to vary the cut-off or reverse the engine. Cross-head connections are eliminated, the valve movement being derived from the eccentric rod and a bell crank. This motion also gives a quick port opening by the valve. These new valve gears have merit, and are coming into extensive use.

Economy of fuel and water have been studied by the leading engineers of the world, among them being Joseph Beattie, late locomotive superintendent of the London & Southwestern Railway (England). In 1856 he built a remarkable locomotive, which is illustrated in Fig. 3. This engine weighed about 25 tons and hauled some of the fastest express trains at that time. The upright cylinder in front of the smokestack was a feed-water heater, through which the exhaust steam was passed, where it came in contact with water from a circulating pump. This water was thus heated to near the boiling point, and what was not immediately required for the boiler feed was forced back, along with the condensed steam, into the tender, heating the water there. A portion of this water was intercepted by the boiler feed pump and forced through a surcharging chamber in the smoke box, which raised its temperature above the boiling point before it entered the boiler. The fire box was divided transversely into two compartments by an inclined water space, each compartment having its own fire door, grate, and ash pan. The rear, and larger, compartment was arched with perforated tiles, and a combustion chamber in the boiler was nearly filled with perforated fire bricks. The gases from the rear furnace thus passed through the tile bridge, over the hot fire in the front furnace, and there ignited, passing through the bricks in the combustion chamber, and thence through the flues. The writer has seen these engines at work. They burned bituminous coal and consumed their smoke perfectly, showing a fuel economy of over 15 per cent.

During the period under notice, much attention was given to balancing the reciprocating parts of locomotives. Many designs were brought out, but only one can be noticed here, and is illustrated in Fig. 2. This was a four-cylinder balanced engine, the cranks being oppositely disposed. It was designed by John Haswell, a British engineer, and was built in 1861 for the Austrian State Railways. This engine weighed about 34 tons and ran with remarkable steadiness. Although it was a simple engine, it was the precursor of the modern four-cylinder balanced locomotive; but before this latter engine came into the field, a number of two- and three-cylinder compound engines were tried. These were efficient until the time came when the great size of the low-pressure cylinders made them too large for the clearance limits of platforms, bridges, and tunnels. Four-cylinder compounds, with all the cylinders outside the frames, were subject to the same limits; and so, about fifteen years ago, this class of engine, having a different arrangement of cylinders, came into use. A notable example of this design is a French express locomotive, which began service on the Chemin de Fer du Nord five years ago. It hauls some of the fastest trains in the world and, with the tender, weighs 158½ tons. The cranks are balanced, with the high-pressure cylinders outside and the low-pressure cylinders inside the frames. The steam is superheated and the fuel is fed by a mechanical stoker. This fine engine was illustrated in the Scientific American of December 16th, 1911.

Another class of compound locomotive has all the cylinders outside the frames. This system is a feature of the Mallet engine, which came in about the year 1888. The latest example is illustrated in Fig. 7, which shows the heaviest and most powerful locomotive in the world. It has three pairs of cylinders, one pair being under the tender. The total weight of the engine and the tender is 426½ tons. This locomotive is working on the Erie Rail-

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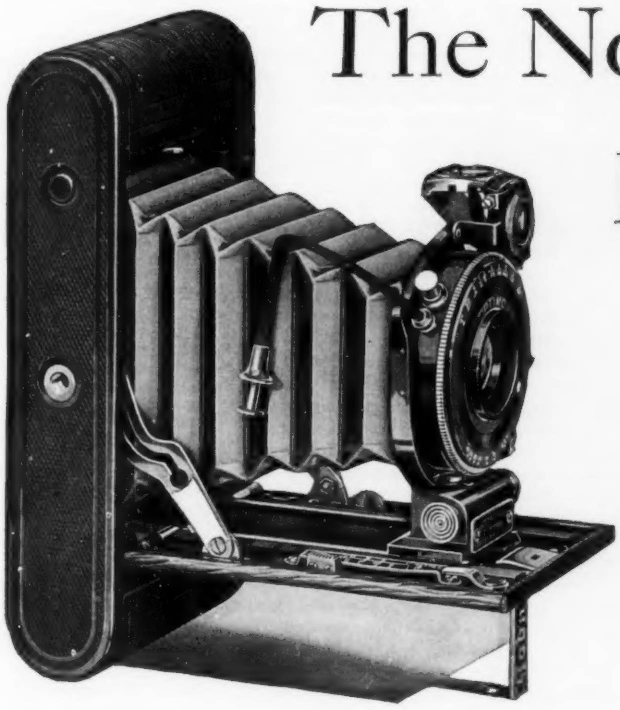

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We have worked for eight years on this Truck Tire problem. We built 29 types before arriving at this one.

We built 74 models of this S-V type before we attained this perfection.

We give you in it, as compared with others, 20 per cent more available tread rubber.

The shape ends bulging, breaking or excessive grind.

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The tire can't creep, as we press it on at a minimum of 50,000 pounds. It can't separate, for the tread, the backing and the rim are welded into lasting union.

Go to a Goodyear Distributor or ask our local branch where you can get this warrant on the latest S-V tire. Accept it while the offer lasts.

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(2374)

road and was fully described in the SCIENTIFIC AMERICAN of June 13th, 1914. It has a feed-water heater, a fire brick arch, a superheater, and a mechanical stoker. These last two improvements have done more than any others to increase the efficiency and output of the steam locomotive, thereby helping it to retain its place in successful competition with the electric motor. By superheating the steam, cylinder condensation is reduced, and the increased volume of superheated steam results in more work being performed with the same quantity of water. Superheating is not new. About the year 1859 some British-built locomotives worked successfully with smoke-box superheaters.

In the matter of coal consumption, when we consider that the fireman of a modern locomotive has to shovel coal into the fire box at the rate of about 6,000 pounds an hour, or 100 pounds per minute, it is evident that on the largest locomotives hand firing is impractical. The Erie engine (Fig. 7) is equipped with a Street mechanical stoker, which is illustrated in Fig. 6. It consists essentially of a screw conveyor for passing coal from the tender to the locomotive, an elevator for raising it to a point above the fire door, a system for regulating its delivery to the fire box, and a distributing system for spreading it over the grate. Over six hundred of these stokers are now in successful use, increasing the earning power of the locomotive from 10 to 20 per cent.

In the year ended June 30th, 1914, the steam railways of the United States spent over $250,000,000 for locomotive fuel; and the cost of fuel is increasing. Experiments conducted during the past year have demonstrated that pulverized coal is the coming fuel; for, even with low grades of coal—now considered useless—practically perfect cumbustion with absence of smoke has thus been obtained. This new system should open the way for a marked reduction in expenditures for fuel on railways.

Electrifying Steam Railroads.

It was inevitable, in view of the success of the trolley car, that electric traction should ultimately be applied to steam railroads. The first main line steam railroad in this country to make use of electric traction was the Baltimore & Ohio Railroad, which as far back as 1895 built some powerful 100-ton electric locomotives for hauling its trains through the Belt Line tunnel at Baltimore. Following this came the electrification of the Valtellina line in Italy. By far the most ambitious attempt, at the time it was inaugurated, to apply electric traction on a large scale to a great railroad system was the electrification of the terminal and suburban lines on two of the most important railroads in America, namely, the New York Central and the New York, New Haven & Hartford Railroads. Each of these is a four-track road and each handles an extremely heavy service. Both installations were forced upon the companies by legislative action—the result of a serious collision in the tunnel leading into the Grand Central Terminal Station, New York. The New York Central road is operated on the direct-current system, and that of the New Haven Railroad by the alternating system. The New York Central zone covers 52.5 miles of road, 255 miles of track, and employs 63 locomotives. The New York, New Haxen & Hartford Company has over 100 miles of road electrified, 606 miles of track, inclusive of yards and sidings, the system being operated by 100 electric locomotives. The progress of the electrification of steam roads throughout the world is shown in the table from a bulletin of the United States Census Bureau of 1912, which is published herewith. The latest direct-current locomotive used on the New York Central in express passenger service, which is an improvement upon the one shown in our illustration, has a speed of 60 miles an hour, drawing a 1,200-ton train. The complete weight of the locomotive is 132 tons, the drawbar pull is 66,000 pounds. The working conductor is a special type of under-running third rail.

STEAM RAILROAD ELECTRIFICATION.*

Name of Railroad.	Miles of Road.	Miles of Track.	No. of Loco.
Principal Main Line Electrification in Service.			
New York, New Haven & Hartford	88	500	100
Spokane & Inland Empire	168	187	12
Butte, Anaconda & Pacific	27	90	17
French Southern	165	205	16
Baden State	10	31	34
Prussian State	19	50	13
Italian State	104	156	84
St. Polten-Mariazell	63	68	14
Ratische Mountain	46	48	11
Bernese Alps	52	55	16
Principal Terminal or Passenger Service Electrifications in Service.			
New York Central	50	240	47
Pennsylvania	15	72	35
Long Island	100	250	..
West Jersey & Seashore	75	150	..
New York, Westchester & Boston	19	63	..
Southern Pacific	50	100	..
Metropolitan Railway, London	35	70	20
London, Brighton & South Coast	60	160	..
Paris-Orleans	14	46	11
Hamburg Ohlsdorf	17	41	..
Main Line Electrification to be Completed in 1914 and 1915.			
Norfolk & Western	30	85	25
Pennsylvania	20	90	..
Canadian Pacific	30	43	4
Chicago, Milwaukee & Puget Sound	113	168	14
Northeastern, England	18	44	10
Swiss Federal	93	100	20
Swedish State	80	93	13
Prussian State	81	124	44
Vienna Pressburg	42	50	16
Italian State	32	60	8

* U. S. Census of 1912.

The electrification of the New York, New Haven & Hartford Railroad has been completed through to New Haven, covering a distance, including the New York Central Line, Woodlawn to New York, of about 75 miles. The passenger service is operated by means of 100-ton locomotives, which are rated at 1,000 continuous horsepower each. For light trains a single locomotive is used, and two for through heavy express trains, which, together, in hauling such a train at 60 miles per hour, develop on level track about 1,500 horse-power. Alternating 13,500-volt current is developed and transmitted through an overhead line. This line has also in operation a very successful freight service, the engine of which weighs 110 tons, and is capable of developing momentarily a tractive effort of 40,000 pounds and a continuous effort of 12,000 pounds. These are geared locomotives of 1,400 horse-power each, designed to haul a load of 1,500 tons in through service at 35 miles an hour. Two of these locomotives coupled up can take care of a trailing tonnage averaging from 2,500 to 3,000 tons.

Thus far no comparative figures of cost of operation have been published by which to judge of the relative economic efficiency of the direct and alternating systems as thus indicated for steam road electrification. The prevailing opinion is that the direct current is preferable for terminal and suburban service and the alternating current system for long-distance work. The raising of the voltage in direct-current service, however, has made the latter a strong competitor of the alternating current in long-distance through service.

Seventy Years of Civil Engineering

(Concluded from page 529.)

Bristol, England, is a motto in Latin, which translated would read, "It is difficult to build a highway through the air." In another chapter of this issue we show how the subsequent development of the steel industry made it possible to build highways through the air on a scale of magnitude undreamed of by our fathers. There is a limit, however, to the length of bridges, or at least to the length of the individual span in bridges, and this was realized when it came to the question of providing direct unbroken railroad communication with New York city. Plans were drawn for a vast suspension bridge with a span of 3,200 feet between towers, and the western railroads centering in Jersey City, headed by the Pennsylvania, were discussing the advisability of building this bridge when the development of electric

Cadillac Standard of the World

More than 10,000 Eight-Cylinder Cadillacs are now in the hands of users

and dealers have placed orders for 10,000 more

HUB CAP
OF THE CADILLAC "EIGHT"

MORE than ten thousand Cadillac "Eights" are now in the hands of users.

Dealers can see a demand ahead so great that they have placed orders for ten thousand more. Figures so large—involving a sum of money so vast—point irresistibly to one conclusion.

The conclusion is that the usual large Cadillac clientele has been enormously augmented by this Cadillac "Eight."

The demand is not merely the normal Cadillac growth, but it is the opening up of the new spheres of influence, and an inrush of new Cadillac admirers and enthusiasts.

It has assumed the proportions of a national movement, at least among those who own, or wish to own high grade cars.

This excess over normal comes from many sources but it is chiefly made up:

First, of the great number who are glad to pay more for the Cadillac because of the Cadillac "Eight" advantages, and

Second, a very great number who are glad to pay less for the same excellent and satisfying reason.

It is frequently said that no company, other than the Cadillac, could have won such immediate and universal acceptance for any principle representing so wide a departure from conventional practice.

And it would seem that there is verification of this in the attitude of the two classes of buyers just mentioned.

Those who are willing to pay more, and those who are glad to pay less, accept the Cadillac "Eight" with equal eagerness—because of the performance of the car itself and because of the reputation of its maker for producing only that which it knows to be right.

They are no more insistent on a "demonstration" than old Cadillac owners—though it is only fair to say that a drive of but short duration immensely increases their enthusiasm.

This latter experience arouses even the most phlegmatic and non-committal.

The reports which they carry home, and to their clubs and to their places of business, largely explain why Cadillac dealers have ordered ten thousand more of these cars.

Has the full wonder of this demand been borne in upon you?

Have you thought of it in the light of the fact that the Cadillac is not a "low-priced" car,—as the term is commonly used?

The huge volume attained by cars of low price is a wonderful thing in itself—a sort of economic phenomenon.

But is it not much more wonderful that a high grade car should command such a market as this Eight-Cylinder Cadillac has won?

There is no other situation at all like it in the automobile industry.

It is not merely a figure of speech to say that the Cadillac "Eight" stands alone.

It does stand alone—absolutely and unapproachably alone—in point of performance.

It likewise stands alone in point of demand and of sales among high grade cars.

And, of course, it would not be so, if it ought not be so.

As you ascend in the scale of prices, the number of those able to purchase grows fewer.

If the Cadillac "Eight" had not preserved every Cadillac tradition and added new and potent powers of attraction—this great market would simply not be here.

There would not be and could not be the marked disparity in volume between the Cadillac "Eight" and those immediately above and below it in price.

It is a sort of a re-adjustment of the national view-point—a re-alignment of buyers—some leaving one field, and some leaving another, and most of them concentrating on the Cadillac.

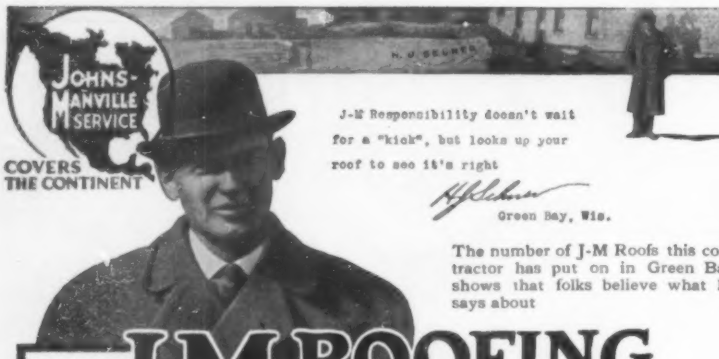
Thus far we have found no one who has ridden in the Cadillac "Eight" who does not say that this is precisely as it should be.

With the Eight-Cylinder Cadillac performing in ways distinctly its own, performing in ways which have heretofore been believed impossible in any car, there is nothing strange in the fact that dealers recognize that the visible demand is not yet half satisfied.

Styles and Prices

Standard Seven passenger car, Five passenger Salon and Roadster, $1975. Landaulet Coupe, $2500. Five passenger Sedan, $2800. Seven passenger Limousine, $3450. Prices F. O. B. Detroit.

Cadillac Motor Car Co. Detroit, Mich.



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The number of J-M Roofs this contractor has put on in Green Bay shows that folks believe what he says about

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J-M Transite Asbestos Shingles
Fire and weather-proof, last forever. Lighter than slate. Mottled Brown, Gray, Indian Red—highly artistic.

J-M Asbestos Ready Roofing
Weather-proof, protects against fire. Needs no coating. Unequalled on wood sheathing and for all slope roofs. First cost only cost.

J-M Asbestos Built-up Roofing
A monolithic structure, permanent, and protects against fire. Lightweight, smooth surfaced, perfectly clean, needs no paint. The imperishable flat roof.

J-M Regal Ready Roofing
Best of "Rubber Type" ready roofings. Excellent for general roofing purposes.

J-M Roofings for Every Requirement

J-M Responsibility is a Johns-Manville business principle.

The practical application of this principle to you and to your J-M Roof is provided in a new feature of our service known as

J-M Roof Registration

When you register your J-M Roof with us you say: "Here is my roof; look after it for me." We can—and will—do just exactly that; for there are enough of us to do it. We cover the continent.

You do your part when you take J-M Roofings on our word that they are the best and most economical roofings you can buy.

Our part is to see that J-M Roofings give complete satisfaction—that they give the Full Service they are meant to give.

Register your J-M Roof with us and J-M Responsibility, backed up by financial stability and highest commercial character will assure you permanent satisfaction.

J-M Asbestos Roofings are examined and approved by Underwriters' Laboratories under the direction of the National Board of Fire Underwriters.

Write us about the building you wish to roof. Our roofing experience goes back fifty years, on all kinds of buildings, and we can advise you to your advantage. We will also send you Roofing Literature of value.

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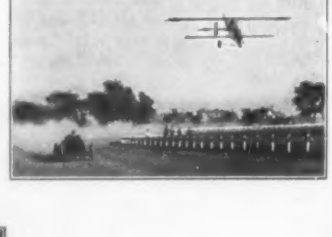
GRAFLEX CAMERAS

You can make snapshots indoors if you use a Graflex Camera. This picture was made indoors with the shutter set at 1-35 of a second. The negative had plenty of exposure, and the shutter operated fast enough to prevent the movement of the children from spoiling the picture.

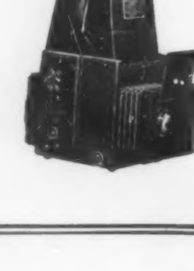
No camera equals the Graflex for high speed photography. In this picture both the automobile and biplane were going at a very high rate of speed. This made it necessary to set the shutter at 1-1000 of a second to get a picture that was clear and distinct.



Photographs in the deep woods or in the shade offer many difficulties to those who are not equipped with a Graflex Camera. With the Graflex you can make pictures under light conditions that make photography impossible with cameras of the usual type.

With the Graflex Camera you can make exposures of any duration from "time" to 1-1000 of a second. You see the image on the focusing screen, right side up, the size it will appear in the finished print, *up to the instant of exposure.*

Our 64-page illustrated catalog tells why the Graflex is the best camera for your work. May we send you a copy?



FOLMER & SCHWING DIVISION
EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK

traction, with its absence of smoke, steam and cinders, pointed to a new way of solving the problem, namely, by electrically-operated tunnels. The bridge was discarded, at least for the time being, and the Pennsylvania Railroad built two main line tunnels under the North River and the Hudson & Manhattan Railway Company burrowed beneath the same great waterway with its four separate tunnels. The Pennsylvania crossed the East River with four tunnels and the New York subway drove beneath the same river with its two tubes connecting its system with Brooklyn.

If these great works were rendered operatively successful by the development of electric traction, they were rendered constructionally possible by the development, many a decade before this, of an ingenious excavating device known as the Greathead shield, the credit for the development of which should be divided among several inventors.

The fundamental difficulty in driving a tunnel beneath an estuary or river, and therefore through material which is more or less fluid, lies in the fact that means must be taken for preventing the inflow of the material to the heading of the tunnel while it is open for excavation work. The use of pneumatic pressure, together with a shield of the general cross-section of the tunnel provided with a cutting edge, solved the problem. Credit for the inception of this method goes to that many-sided and brilliant French-English engineer, Sir M. I. Brunel. He secured his first patent for a tunneling shield in subaqueous material in 1818 and used it in building the first tunnel under the Thames River, London. Brunel's shield was rectangular; but in 1865 Peter W. Barlow, an English engineer, patented in England a method which employed a circular shield with a cast-iron lining of the completed tunnel back of the shield. Four years later he was associated with another English engineer, James Henry Greathead, in building a tunnel under the Tower of London, 1,350 feet long and 7 feet in diameter, which was completed in less than a year, a remarkable record at that time for work of this character. In 1869 Alfred Ely Beach patented a method of using hydraulic rams abutting against the lining of the completed tunnel for pushing the shield forward into the undisturbed material. A later and most important development of subaqueous work was that used in the completion of the downtown tunnels of the Hudson Terminal tubes. This was the displacement method by which, instead of permitting the material to enter the tube through the shield for removal through its approaches, the shield was pushed bodily forward, the fluid material flowing around the tube as it progressed.

The general public is so thoroughly familiar with the engineering features of the subway work which is being carried on in its midst that it calls for no detailed description here. The excavation is now usually done by cut-and-cover work, in which the street pavement is replaced by timber roofing supported on heavy timbering, over which the street traffic passes while the work of excavation is carried on below. In the earlier subways, the roof was supported on steel columns and steel floor beams, arches being thrown in between the floor beams. The latest method is to make the tunnel lining of monolithic reinforced concrete—a cheaper and more rapid method of construction.

Foundation Work and the "Skyscraper."

The method of building deep foundations in loose material, or in such material as is water-bearing, by means of the pneumatic caisson was well established by the year 1845. Credit for the first use of pneumatic pressure in building foundations is given to Smeaton by that great work, Ludwig Darmstaedter's "Chronological Handbook of Natural Science and Technology." This author states that in 1778 Smeaton sank the foundations for a bridge at Hexam, Northumberland, by the use of compressed air. In 1849 the French engineer, Triger, made use of the pneumatic caisson for driving through river sand at Chalonnes, France. A method used successfully in sinking foundations in the bed of rivers is that of the open cofferdam, a notable instance of which was the construction of the foundations for the Hawkesbury Bridge in Australia, which was built by American engineers. In this method, the excavation is done by means of dredges, generally of the clam-shell type, which excavate the material within the shell and thereby cause it to settle to the desired level. The most important use of the pneumatic caisson in the period from 1880 to 1890 was the construction of the massive piers for the Forth River Bridge. The cylinders were built with a double shell and provided with a massive cutting edge at the perimeter of the outer shell. At a suitable distance above the bottom, a strong, heavily-trussed steel roof was provided, and from this shafts provided with air locks led to the surface, one of them being used for the entrance and exit of the working crew, the other for the unloading of the excavated rock and other material.

The most extensive use of pneumatic caissons has occurred in the city of New York, in preparing the foundations of some of the tallest buildings in the world. Manhattan Island consists mainly of gneiss rock of very irregular contour, overlaid with river sand; the depth to rock varying from a few feet to two hundred feet and over. With the introduction of the skeleton-steel frame building, the weight of the superstructure was concentrated at certain defined points over the whole area covered by the building. In preparing the foundations, pneumatic steel caissons are sunk through the sand to a bearing upon solid rock, the caissons being filled subsequently with concrete up to the level of the footing of the steel columns. The building laws allow a maximum load of 15 tons per square foot, and upon this loading it has been possible, without exceeding the limit, to erect buildings to unprecedented height. The modern steel building, especially in the later types, is absolutely fireproof, the columns, the floor beams and all the main steel structural work being incased in terra cotta or some other fire-resisting material. The outer walls and interior partitions are carried by the steel framework, and this has made it possible to avoid the accumulation of pressure and consequent thickening of the lower walls, which were unavoidable in the tall buildings that preceded the age of steel construction. Had it not been for the introduction of the elevator, the towering office buildings of the present day would have been impracticable, but with their introduction and subsequent improvement, and notably because of the high speed at which they are run, there is no limit, so far as accessibility is concerned, to the height to which skeleton-steel buildings may be carried. The two loftiest structures of this kind in the world are the tower of the Metropolitan Life Building, which is 700 feet in height, and the 785-foot tower of the Woolworth Building, which is the highest office building in the world, and the highest structure of any kind with the exception of the Eiffel Tower. The future limitations of tall buildings will be due to legal restriction rather than to any inherent structural difficulties. Some years ago the SCIENTIFIC AMERICAN requested an engineer to prepare plans, showing to what height a building might be carried without exceeding the unit pressure of 15 tons per square foot, and it was found that, on a base 200 feet square, it would be possible to erect a structure that was 2,000 feet high, and that this building would be perfectly safe in the heaviest tornadoes that might blow against it.

The Invention and Development of Photography

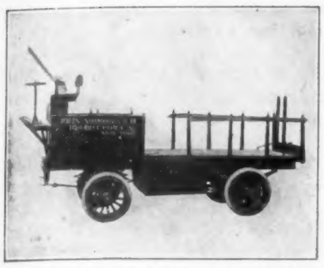
(Concluded from page 530.)

solution of bichromate of potash darkened when exposed to light.

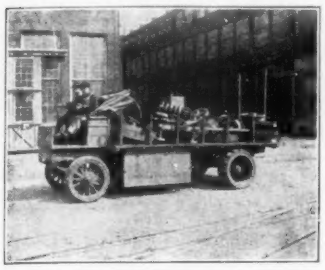
The next was the discovery that gelatine, gum and other bodies were rendered wholly insoluble when exposed to light in combination with bichromate of potash.

A True Exponent of Progress—

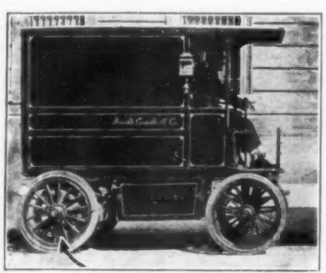
THE G.V. ELECTRIC TRUCK



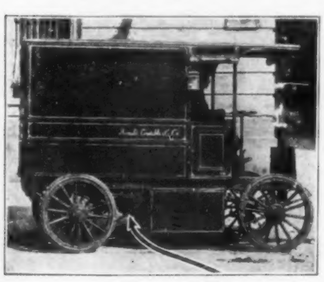
1—A 5-ton G. V. Electric built 1901. Double motor pinion drive. Note the overhang in front and the relatively crude steering mechanism.



2—A 5-ton G. V. Electric built 1912. Single motor chain drive. Contrast this with the truck above.



3—G. V. Electric built 1902. Double motor *pinion drive*. Plain bearings. Right side lever steering. Mileage per charge 25.



4—G. V. Electric built 1907. Single motor *chain drive*. Steering wheel in centre, roller bearings. Mileage per charge 40.

5—G. V. Electric built 1914. Single motor *worm drive*. Long wheel base, steering wheel at left. Battery under hood. Two sets of brakes, interlocking safety devices. Mileage per charge 45-65

6—Modern 5-ton G.V. Electric brewery truck. This brewer has gradually added to his G. V. fleet until to-day he has 126. He started in 1903.

THE "Scientific American" has recorded no more interesting phase of industrial progress than the growth of Motor Transportation. A decade or so has seen the city truck horse superseded by a trackless machine. A few years have modified our entire system of handling merchandise, at least in the larger cities.

And in this march of progress, in this inevitable working of economic law, the Electric Truck—and especially the G. V. Electric truck—has had an important part. It was the pioneer—the first motor competitor of the city horse.

A glance at the illustrations will show, in part, the evolution of the G. V. Electric. It was a trucking factor before the two cylinder automobile was efficient. In spite of the limitations of early design and power plant—in spite of prejudice and competition—it has steadily forged ahead. Today there are nearly 2,000 General Vehicle Electrics in daily service in New York City alone. This is more than 25% of all trucks employed in the city. G. V. Electrics are operating in 42 of the 48 states and 9 foreign countries.

A Growing Confidence in Electric Delivery

Now that the Electric truck has demonstrated its long-lived efficiency —now that it is better understood— there is a growing confidence in the Electric method—yes—the Electric principle—of trucking and delivery. The more efficient motor trucking becomes the more Electric trucks will be used in their field. And this field takes in fully 80% of all average city work. This is being recognized and shrewd men are profiting thereby.

The Electric is *not* a competitor of the Gasoline truck. Both have their economical fields in which they are fundamentally superior. The trouble has been that some business men have ignored the Electric and paid an unnecessary premium on other forms of delivery in the Electric's field.

Twenty-five (25) big city firms already use 1,116 G. V. Electrics. This shows the logical preponderance of the high grade Electric in the city. Other firms are systematizing their delivery service and giving the horse, the Electric truck and the Gasoline truck each their economic place. The scientific application of motor trucking to his business should be studied by every business man and in that study we can help. And this is why:

The Complete G. V. Line Includes All Types of Motor Trucks

Engineering counsel and co-operation can best be supplied by the strong, experienced manufacturer of motor trucks. The General Vehicle Company has developed *a complete line of commercial motor vehicles*. It builds *gasoline* trucks as well as electric trucks, *industrial* (or internal service) trucks, as well as road trucks. It has even supplied *gas-electric* trucks for special purposes. Six Electric models ranging from 1,000 to 10,000 pounds are provided and both worm and chain drive are available in the lightest types. Patrol wagons, street sprinklers, ambulances, power-dumping bodies, trucks equipped with winches and hoists, street cleaning tractors, trailers and many other types are provided. The Industrial Division, supplies Electric industrial trucks (as illustrated), industrial tractors, including "Electric mules" for the lumber trams, crane trucks and similar apparatus. No other manufacturer is in a position to so well serve the varied needs of the truck buyer as the long established General Vehicle Company.

We are prepared to impartially fit the right vehicle to the exact need. To supplement the Electric truck with the gas truck or to displace the hand truck. *Specific adaptability* is our watchword. This is why you can bring your trucking and delivery problem to us with every assurance of practical co-operation and help.

Catalogue 101 contains fascinating figures on ready-to-your-hand returns on improved delivery. Why not write for it?

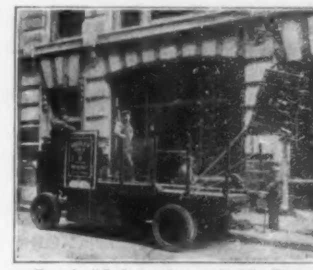
General Vehicle Company, Inc.

General Office and Factory

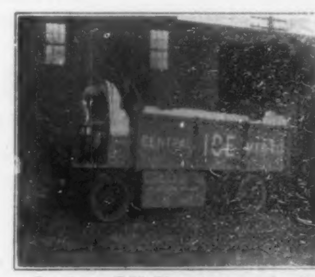
Long Island City, New York

NEW YORK CHICAGO BOSTON PHILADELPHIA

7—5-ton G. V. Mercedes (gasoline) Truck. The United Dressed Beef Co. operate 28 G. V. Trucks; 25 Electric and 3 Gas. The latter for the long fast hauls.



8—A Modern 5-ton G. V. Electric with winch. This winch is fed from the same battery which drives the truck. Very efficient.



9—5-ton G.V. Electric ice truck. One customer uses three with dump bodies for moving crushed ice. We have been very successful in the coal hauling problem also.

10—2000 lb. G. V. Electric Industrial Trucks. Hundreds of these are demonstrating to the manufacturer, the railroad and the steamship company that the hand truck, like the truck horse, is becoming obsolete. These Electric "stevedores" frequently displace 15 men each.

11—G.V. Electric worm drive patrol wagon. Practical, efficient, economical. Ample speed and mileage; compare it with the Lord & Taylor wagon.

12—G. V. Electric Street Cleaning Tractor. Very powerful and efficient. We are building 12 others for one city at the present time. Bring your problem to the General Vehicle Company.

Answer this Question?

Have you looked into the efficiency of the Counting, Weighing, Shipping, Handling, Trucking of your material?

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You are Losing Money
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We will guarantee to prove this to you if you will let us go into the matter. We are Efficiency Experts. It costs you not one penny unless we make you money, as we guarantee—50 to 90% saving.

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The men who are pouring the concrete follow fast on the heels of the men who lay the Self-Sentering. No time and expense for forms—temporary construction is unnecessary.
Self-Sentering is a combined centering and reinforcement. Think what cutting out forms would mean in the money and time cost of your proposed new building. But

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Pat. March 3 1914 [*You'll Know It by Its Diamond Mesh*] Other patents pending

cuts more than the cost of forms. It lightens construction.
With Self-Sentering your everlasting concrete roofs, curtain walls, partitions, etc., need be but two inches thick. Can be adapted to all shapes and designs. You can have arched or flat floors. Gauge for gauge, Self-Sentering has a greater sectional area than any other similar form. For required strength, Self-Sentering construction is, therefore, the lightest.

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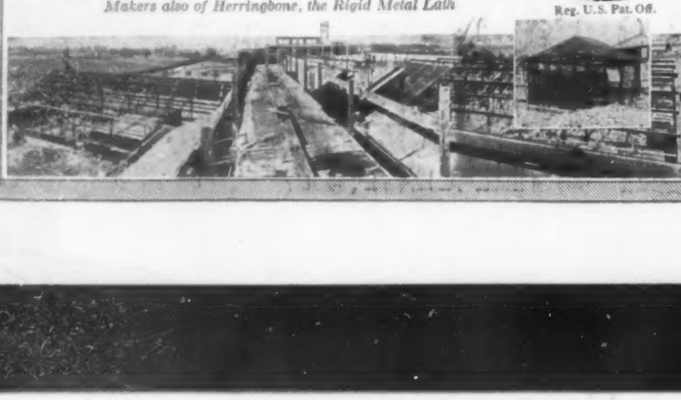

This observation was first made by Mr. Becquerel.

The next idea evolved was that gelatine made insoluble by light, might be made to imprison particles of coloring matter. Where light acted, these would remain; where it did not act they would wash out by reason of the insolubility of the portion of the film in which they were contained. This was an important step and was made by Poitevin in 1855. The carbon process now used was invented and patented in 1866 by J. W. Swan.

The Introduction of Dry Plates.

Although dry plates were proposed as early as 1854 by Gaudin in France and Muirhead in England, J. M. Taupenot seems to have been the first to have invented a practical dry plate. His process was cumbrous. It was not until Major C. Russell introduced the alkaline developer (1862), which necessitated the employment of silver bromide on the sensitized glass, that the dry plate really became workable by anyone. His dry plates are the forerunners of those we now employ in photography.

Up to the time of W. B. Bolton and B. J. Sayre's experiments (1864) silver iodide had been considered the staple of a sensitized film on which to take negatives. It occurred to them to bring the sensitive salts of silver in collodion while liquid and to form a sensitive film merely by letting the collodion, containing the salts in suspension, flow over the glass plate. Thus, the collodion emulsion process was born—a process which revolutionized photographic manipulations. M. Carey Lea of Philadelphia and W. Cooper, Jr., of Reading, placed the process on a commercial basis by improvements which made the plate more sensitive.

Since silver bromide emulsion could not be prepared in collodion, naturally experimenters began to cast about for collodion substitutes. The researches of Maddox (1871), King (1873), Burgess (1873), but above all the work of R. Kennett (1874) and C. Bennett (1878) resulted in the gelatine emulsion process of making dry plates.

Development of the Photographic Camera.

The first photographic camera of which we have any account was simply a darkened room, the sunlight being reflected through a window by means of a mirror casting an image of the subject upon a sheet of sensitized paper. The next was a plain box with a plate holder fitted to the back, the lens being mounted in a tube and inserted in the aperture in front so that it would slide in or out as a means of focusing. Such was the camera used by Niepce and Daguerre in their earlier experiments, but in 1839 we find Daguerre using a camera composed of two boxes, one sliding within the other, controlled by a brass sliding rod underneath.

Then followed the camera with stationary front, the back sliding upon its base with a set-screw and connected with the front by means of a bellows.

The wagon load of paraphernalia necessary for the amateur's traveling outfit in the seventies and eighties, while it did not deter an enthusiast here and there, did prevent anything like widespread interest in photography. To simplify these processes and lighten the camera equipment itself were the problems that fell to the American inventor, George Eastman.

Dry plates were too heavy and cumbrous for the amateur. A thin, rollable, continuous, transparent strip, which would carry the negative, was required—something unbreakable and light. That need was supplied by the celluloid film which was invented by the Rev. Hannibal Goodwin in 1887. There can be no doubt that the celluloid film was also independently worked out by Eastman and his chemists; certainly the commercial film came from Eastman and his associates.

That the film camera—the kodak as we now call it—became as popular as it is must always be credited to Eastman. He and his chemists had worked on the film idea for years. They certainly developed a commercially practical method of producing films cheaply—at first using greased paper and finally adopting celluloid.

The important Eastman invention—the kodak—was a logical outcome of the roll film idea. The first kodak appeared in 1888. It took round pictures 2½ inches in diameter, had a fixed focus, and carried a roll of one hundred exposures. Compared with the little hand cameras we carry to-day, with so much pride, it was a rather crude and clumsy affair. But it marked a giant stride, and relieved the amateur of so much of his burden that photography henceforth became a pleasure instead of a drudgery. Its evolution proceeded simultaneously with the film discoveries, the evolutionary stages involving daylight loading, first by means of a black protecting cloth at each end of the spool, and later by the present cartridge system. This latter rendered obsolete all earlier kodak models and marked the beginning of the compact, convenient, and dainty models of to-day.

Photographs in Natural Colors.

Long before the hand camera became as popular as it is, long, indeed, before photography became a general pastime, the taking of photographs in their natural colors engaged the attention of scientific men.

The original process used by Clerk Maxwell in his famous lecture at the Royal Institution in 1861 was an additive process, for he projected on a screen three lantern slides made from three negatives taken of a colored ribbon by means of three lanterns in front of which were glass troughs, these containing, respectively, sulphocyanide of iron, which is red; chloride of copper, which is green; and ammonio-copper sulphate, which is blue-violet in color. The lantern slide taken by red light was projected by red light, that from the negative taken by green light was projected by green light, and that taken by blue light was projected by blue light, the three pictures being superposed on one another, so that a colored image was seen on the screen, of which the report says: "If the red and green images had been as fully photographed as the blue, it would have been a truly colored image of the ribbon." This imperfection of Maxwell's result was undoubtedly due to his lack of photographic material appreciably sensitive to any colors other than blue-violet.

Since this first experiment the additive process of three-color projection has been used by many workers, the best known being Ives. In his famous "Kromskop" he modified the principle so that his apparatus could be used both for protection on a screen and also as a view instrument to be used by an individual observer.

An entirely different application of the additive process of color photography is found in the screen plates, of which the best known example is the Lumière autochrome plate. The possibility of this method was first indicated by Ducos du Hauron in 1869, in the little booklet entitled "La Photographie des Couleurs," in which he outlined many of the processes of color photography which have since been realized in practice. The principle of the screen plate process is to divide the surface of the plate into a number of microscopic filter units—red, green, and blue-violet—and then to take the picture through these units upon an emulsion from which a positive is made either by reversal or by the ordinary photographic methods, this positive being registered with the screen, so that when the emulsion was blackened by exposure through one of the filter units, light is transmitted through that unit in the finished picture. The Lumière plate represents this process in its simplest form, the filter screen being coated upon glass and the emulsion on top of the screen, while the negative itself is reversed and converted into a positive, so that it remains always registered with regard to the screen.

The subtractive processes depend upon the generation of colors by the superposition of the three complementary colors—blue-green, magenta, and yellow. Where magenta is superposed by yellow, we get


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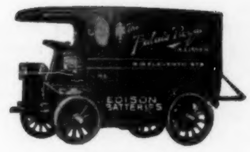
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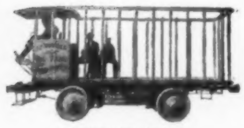
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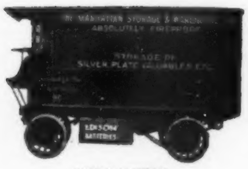
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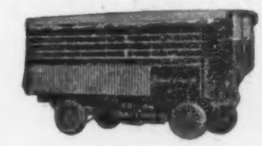
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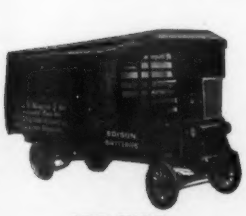
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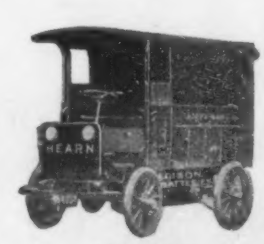
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primary red, the yellow absorbing the blue and the magenta the green light, so that only the red constituent of white light is left. By superposing the three in the requisite proportions, all colors can be reproduced. The method adopted in practice is to make three negatives through the three color filters just as in the additive process, and then to print positives from these negatives in such a way that the image consists of a colored dye, the commonest method being to print the negatives in bichromated gelatine. Three negatives are printed by this process, the negative taken through the red filter being printed on gelatine which is dyed blue-green, the one through the green filter on gelatine dyed magenta, and the one through the blue filter on gelatine that is dyed yellow. When the three colored transparencies are cemented together on top of one another, the result completely reproduces the colors of the original object. This transparency may be viewed in the hand or examined in front of an artificial light or projected in a lantern, or instead of this, a paper may be made by stripping off the three gelatine reliefs on paper; and some very beautiful results have been obtained in this way.

The simplest possible subtractive process will be one in which the original negatives themselves are directly transformed into color positives; therefore, the simplest possible color process will be one in which two negatives taken under two filters are directly transformed into the partial pictures for the two-color process, the red negative being turned into a green positive and the green negative into a red positive, and the two then superposed face to face to make the completed picture. Such a process would employ no loose films and only the minimum number of glass plates, while there would be no transferring of pictures from one glass to another. The final difficulty of registering also is reduced to a minimum. Moreover, if the original negatives can be actually transformed into a color positive, we may expect to retain in the positives all the gradation in the original negatives. The gradation by this process should consequently be as good as can possibly be obtained. Also, since there is no screen and the high-lights are represented by clear, unstained gelatine, the transparency of the picture should be equal to that of a black and white subject.

The direct transformation of a negative in black silver into a positive in which the silver of the negative was represented by clear gelatine and the places that were lightest in the negative by a full strength of any colored dye that might be chosen, the transformation being correct throughout, so that all the gradation of the original negative was reproduced in the resulting positive was a problem never satisfactorily solved until it was attacked in the research laboratories of the Eastman Kodak Company. It was this specific problem of transforming a silver negative into a dye positive, the working out of which made the new two-color "kodachrome" process possible.

The method adopted is to make the negatives on specially prepared panchromatic plates and through the correct filters, and then develop them as usual. They are then chemically treated so as to remove the black silver and leave the plate looking just like the colorless sheet of gelatine, showing no sign of an image. When this plate is put into the specially prepared dye bath, the dye goes into the gelatine most easily where the silver was absent in the negative; that is, where there was least light in the original photograph or in the part represented by deep shadows; while in the parts corresponding to the high-lights, where there was much silver in the negative, the dye penetrates more slowly, so that as the dye slowly enters the film, the original negative is transformed into a positive produced in a colored dye. While the one color is made in this way, the companion picture is also dyed in the other color, and the two, when placed together, make the finished picture. The process is thus seen to be simplicity in itself, the novel point of it being the method which has been worked out for transforming a black and white negative image into a colored dye positive. Since only two colors are used in the process, it is obvious that all colors cannot be correctly rendered, and the colors for which the process fails are the blues, violets, magentas, and purples. Light blues appear blue-green, and violets, black; magentas appear pink; and purples, dark brownish-red. On the other hand, flesh tints of all kinds, and all shades of red, orange or green grays and blacks are well rendered. As these are predominant in portraits, the results are more satisfying for this class of work than for outdoor work.

How the Motion-picture Machine Was Invented.

In a certain sense, motion-picture photography is as old as photography itself. There is abundant evidence of the desire to produce visual representations of objects in motion, evidence embodied in such fantastically named toys as the Thaumatrope, Zoetrope (Wheel of Life), Stroboscope, Phenakistoscope, etc. Most of these are fifty years old and more. The first of them was invented by Dr. Coleman Sellers of Philadelphia, who took out a patent on February 5th, 1861, for what he called his "stereoscopic cabinet," but which came to be known as a "kinematoscope." Sellers must be regarded as the pioneer in the motion picture field.

In these early devices the pictures were usually arranged in a circle on cardboard and viewed through holes corresponding in number with the pictures. The pictures passed before the eye continuously and were seen for a greater or less time, according to the size of the hole. Sellers, the first in the field, differed from his contemporaries and imitators in recognizing the fact that the pictures should be entirely at rest during the moment of vision, a principle essential in motion-picture photography. The three vital features of a modern motion-picture apparatus are (1) a flexible ribbon picture carrier, (2) a mechanism for intermittently holding it before a lens, and (3) a place for the exhibition of the pictures to a great many people at the same time. Sellers's apparatus fulfilled the first two of these conditions; but his apparatus exhibited its pictures to one person at a time only. Because he introduced the intermittently moved ribbon-like picture carrier, however, Sellers is in a sense the father of motion-picture photography. Ducas of France in 1865 patented a ribbon-like picture carrier, the latter controlled by sprockets. Then came Donisthorpe, an Englishman (see *Nature*, January 24th, 1878); Marey of Lyons, France (1881), and Reynaud (1889) with the same idea. While all of these adopted and employed perforated picture ribbons, Marey employed the celluloid film.

The First Public Motion Picture Entertainment.

To Henry Heyl of Philadelphia must be assigned the credit of having given the first motion-picture exhibition in the modern sense of the term. That was in 1870. His invention, the "Phasmatrope," was first exhibited in Philadelphia, at the American Academy of Music, February 5th, 1870, before an audience of more than 1,500 persons. The related photographs were small glass plate positives of selected subjects reduced from wet plate negatives, taken from successive poses, by an ordinary camera. The "phasmatrope," or exhibiting device, was a revolving skeleton disk around the periphery of which the glass positives were removably placed to register accurately as they intermittently came into the lantern rays. During the intervals between the rests of the disk a vibrating shutter cut off the light. The rotation of the disk was in absolute control by the operator so that the movements of the figures (two waltzers) were kept in perfect synchronism with an orchestra of forty musicians. Hence, we have here not only motion pictures, but the correlation of sound with motion. Mr. Heyl went even farther. He threw upon the screen a figure of a gesticulating "Brother Jonathan." The pantomimic gestures and lip movements of the moving

1845 - 1915

Seventy Years of the New-York Life Insurance Company

THE New-York Life Insurance Company was organized in the same year the SCIENTIFIC AMERICAN was founded. There were at that time twelve American life companies, and the new insurance written during the previous year was about three million dollars. Of these twelve companies, nine survive, but only four are now taking new risks. The business of all American life companies in 1914—now over 200 in number—was about thirty-five hundred millions. The New-York Life's new business in a single week is now greater than the total yearly business of all the companies when the New-York Life was organized.

But New York was a small city seventy years ago, and the United States was geographically very large. The city had a population of less than 400,000; but one steam railroad—the Harlem—entered it. There were but 27 States in the Union, with a total population of about 20,000,000. There were less than 5,000 miles of railroad in the whole country, and the first iron rail was laid in that year. Chicago had about 10,000 inhabitants, San Francisco about 500, Minneapolis, St. Paul and Kansas City a few hundred, Omaha and Denver none. The first telegram had been sent less than a year before. The expenditures of the United States Government were less than $22,000,000. The slave-ship "Spitfire" was condemned at Boston in 1845, and among the first thousand policies written by the New-York Life were 339 upon the lives of persons of African descent who were held in bondage under the laws of the United States.

The first Annual Statement of the New-York Life showed the following:

Policies issued	**449**	**Expenses**	**$5,191.16**
Amount insured	**$929,038.00**	**Net Assets**	**17,495.55**
Premiums received	**22,622.71**	**Insurance in force**	**799,000.00**
Interest received	**32.33**		

There had been no death-losses. The first death-claim was paid in November, 1846, was for $225, and was paid upon the life of a slave. There was a sort of irony in the fact that his name was Philip Swan! Such policies were always for small amounts, the term one year, with a seven-year rate. Sometimes several lives were insured under one policy; Policy No. 268 was upon the lives of ten slaves and one white man. The issue of slave policies was discontinued by direction of the Trustees in April, 1848.

The policies of the time gave the insured permission to travel and reside in the United States south of Virginia and Kentucky, BETWEEN NOVEMBER 1 AND JUNE 1, and that was considered liberal. To travel outside the settled limits of the United States, Canada, Nova Scotia, and New Brunswick, a permit must be obtained. Policies were absolutely forfeitable for (1) non-payment of premium, (2) death by the insured's own hand, (3) any untrue statement in the application, (4) death upon the high seas, in consequence of a duel, or at the hands of justice, or in the known violation of any law of the United States, or of any State or Province in which residence and travel were permitted. Military or naval service in time of war invalidated the policy.

It is now time to note how far we have come in the matter of business and in policy conditions. The Seventieth Annual Report of the New-York Life shows the following figures for the year 1914:

New Policies written	**107,320**	**Expenses**	**$13,293,067**
Amount insured	**$226,674,121**	**Taxes, other than real estate taxes**	**1,309,601**
Premiums received	**90,467,178**	**Policies in force, Dec. 31**	**1,142,253**
Interests, rents, etc.	**35,799,396**	**Amount insured**	**2,347,098,388**
Paid death-losses	**26,230,268**	**Net assets, Dec. 31**	**799,838,591**
Other payments to policy-holders	**45,741,097**		

The changes in policy conditions have been almost as great as in the volume of business—if such things could be compared. Policies are now written practically without conditions except the due payment of premiums, provided present residence, occupation and habits of life are satisfactory. A suicide clause is operative for one year. Policies are automatically non-forfeitable after two years' premiums have been paid. Loans and cash values are available after two years. Policies are payable in case of death, not only in cash, but other valuable options are available, such as leaving the money with the Company at interest and drawing it out $100 at a time; payment in a selected number of equal annual instalments; an income for life, etc. Under the first of these options the New-York Life will pay the $100 in five $20 checks.

Another late feature introduced by the New-York Life is a disability clause, insuring against total and permanent disability. The benefits include the waiver of premiums due, and the payment of the face of the policy in ten equal annual instalments if the disability continues.

The advantages of life insurance are now so generally recognized that it has been adopted by the state, by business and by society, in one form or another, as the best method of replacing the earning power of the husband and father who dies prematurely.

What will the next seventy years bring to Life Insurance and to the SCIENTIFIC AMERICAN? Many amazing developments in science will be reflected in the pages of this publication. Is it too much to hope that within that period the savagery of international relations may be superseded by the law of human brotherhood—which is the great law of life insurance?

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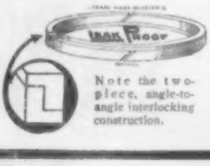

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photographs coincided with the voice of a reader who supplied the audible words.

Perhaps the name of Edward Muybridge is the most conspicuous in the history of chrono-photography, although he was not the developer of motion-picture apparatus in the accepted sense. His remarkable studies of animals in motion were made with a battery of cameras. His work was of more scientific than of commercial value. Muybridge did design, about 1880, his "zoopraxiscope" to exhibit his glass plate positives of animal movements. This was more or less an exact counterpart of Heyl's "phasmatrope."

The devices of Mr. C. Francis Jenkins of Washington, D. C., deserve particular mention, for they seem to have established a type of projector which has continued until now. He was the first to have publicly exhibited in 1893 (before the Capitol Camera Club, Washington), and later in 1894, with an apparatus of a modern type. Lumière gave the first public demonstration in Paris in 1895 with his kinematograph—a combination camera projector which exhibited pictures of remarkable beauty.

In 1889 Edison made his first motion-picture camera in which a film was intermittently moved. His earliest form of exhibiting apparatus, known as the "kinetoscope," was a machine in which a positive print from the negative obtained in the camera was exhibited directly to the eye through a peephole; but in 1895 the films were applied to modified forms of magic lanterns, by which the images were projected upon a screen. Edison, however, was not held to be the creator of the modern motion-picture apparatus in a very important patent infringement suit decided a few years ago. Indeed, it is hardly to be expected that any one man could claim to have created the motion-picture machine as we know it. It is a composite, embodying principles discovered many years ago, each by a single investigator. But Edison certainly did fine work in developing the machine along the line of manufacturing details and much credit is due to him for that.

The standardization of the motion-picture machine is now world-wide. Films made in the most remote corners of the earth fit any machine in any theater anywhere. Hooks, as employed by Lumière, have become standard in cameras, while the intermittently rotated sprocket plan of Jenkins has been adopted on projecting machines in all countries. To Nicholas Power belongs the credit of having introduced many refinements which contributed to the perfection of the projecting apparatus, notably his devices for preventing the ignition of the highly inflammable film as it passes in front of the intensely hot arc light.

Of those who essayed to exploit machines combining motion and sound, not one can be considered pre-eminently successful. It seems no very difficult matter to synchronize the phonograph with the motion-picture projector and, indeed, dozens of patents have been taken out for synchronizing devices. The fault seems to lie more with the sound reproducing devices than with the motion-picture machine. The phonographic voice is certainly not so natural as the animated picture.

Motion-picture Photography in Colors. Motion-picture photography in colors depends upon the same principles as ordinary photography in colors. In addition to one or two processes which are only of laboratory interest, all methods of color photography consist of applications of the three-color theory of vision, depending upon the fact that any color may be matched by a combination in the proper proportions of the three primary colors—red, green, and blue-and-violet. There are two main methods by which the combination of these colors can be achieved and a color picture, either still or in motion, produced, these being termed, respectively, the additive and subtractive methods.

Of the photographic color schemes in chrono-photography, the Smith-Urban kinemacolor process is prominent. This is a process in which two colors are used instead of three. Positives made from a red and green negative are projected alternately upon the screen through red and green filters. While the color rendering in this process is quite pleasing, the correctness is much inferior to that of the three-color process, but the results obtained are sufficiently encouraging to justify the belief that a slight improvement in color rendering over the results obtained by this two-color additive process is satisfactory for many purposes.

One of the latest applications has been the Gaumont three-color process, where three cinematograph pictures are taken on films of the usual width, one over the other, through three lenses, the pictures being somewhat reduced in height so that the three pictures are two and one quarter times the length of the ordinary black-and-white picture, the film being moved after each exposure through the length of the three pictures. Projection is accomplished by means of a very ingenious triple lens, each positive being projected through its own lens system and filter.

Communicating Over Great Distances

(Concluded from page 532.)

opening the old Reis-Bell controversy, it must be said that there is grave doubt whether Reis's instrument ever did or could transmit speech, whereas there is no doubt at all that Bell's instrument did transmit speech. The correct idea of the telephone also occurred to Elisha Gray, who, however, filed a caveat in the United States Patent Office only a few hours after Bell, with the result that all the commercial fruits of one of the greatest discoveries in the world slipped from his grasp Bell's patent has been called "the most valuable single patent ever issued" in any country. That is probably true; for its claims cover not merely an instrument, but the whole art of transmitting speech over a wire. When the telephone was placed upon a business basis by Gardiner Hubbard (to whom America owes very much indeed for the encouragement which he gave Bell and for his business acumen, and broad-mindedness) the Western Union Telegraph Company realized that a formidable competitor of the telegraph had appeared. It organized the American Speaking Telephone Company, and engaged Edison, Gray and Dolbear as electrical engineers. These three men, as well as Berliner, Blake, Hughes, and others, developed the telephone and made it a really practical commercial instrument. In 1877 Berliner invented the loose-contact transmitter and applied the induction coil between transmitter and receiver. These two inventions have ever since been applied in all practical telephony, and no other devices have taken their places in practice. Both of these are essential elements of the telephone as we know it. In Bell's instruments sound vibrations impinge upon a steel diaphragm, arranged adjacent to the pole of a bar electro-magnet, whereby the diaphragm acts as an armature, and by its vibrations induces very weak electric impulses in the magnetic coil. These impulses, according to Bell's theory, correspond in form with the sound waves, and passing over the line, energize the magnet coil at the receiving end, and by varying the magnetism, cause the receiving diaphragm to be similarly vibrated to reproduce the sounds. A single apparatus is, therefore, used at each end, performing the double function of transmitter and receiver. With Berliner's improvement a closed circuit is used, on which is constantly flowing a battery current, and included in that circuit is a pair of electrodes, one or both of which is of carbon. These electrodes are always in contact with a certain initial pressure, so that current will be always flowing over the circuit. One of the electrodes is connected with the diaphragm on which the sound waves impinge, and the vibration of this diaphragm causes the pressure between the electrodes to be correspondingly varied and thereby effects a variation in the current, resulting in the production of impulses which actuate the receiving magnet.

(Concluded on page 570.)

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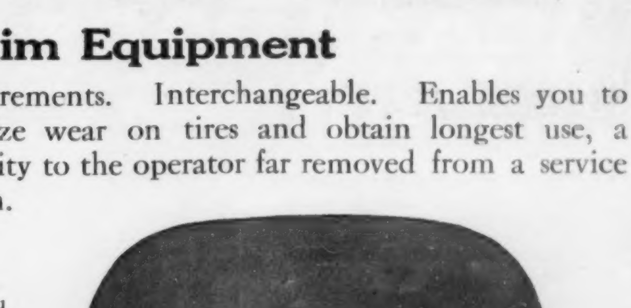

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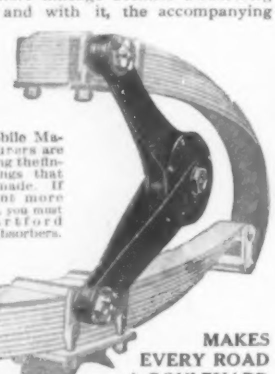

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DEFENSELESS AMERICA. By Hudson Maxim. New York: Hearst's International Library Company, 1915. 8vo.; 318 pp.; 20 illustrations. Price, $2.

The purpose of this timely and excellent work is aptly expressed in the opening paragraph of the preface: "To present a phalanx of facts upon the subject of the defenseless condition of this country, and to show what must be done, and done quickly, in order to avert the most dire calamity that can fall upon a country—that of merciless invasion by a foreign foe, with the horrors with which no pestilence can be compared." While the above expresses the purpose of the book, which is admirably fulfilled, the scope of "Defenseless America" is so all-embracing, that the author has given us a veritable mine of information upon the subject of war and war material. Mr. Maxim is well qualified by his long and successful association, as a practical and successful inventor, with the production of the implements of war, to write upon the technical side of the question; and this he does with a characteristic force and lucidity which will render the subject perfectly understandable and full of fascinating interest for the average layman. We refer, here, to the six chapters entitled: Modern methods and machinery of War; The needs of our Army; The needs of our Navy; Language of the big guns; Aerial warfare; and Our armaments not a burden. The author writes with a trenchant pen and his logic is as merciless as it is pungent. Nowhere are these qualities used with such telling effect as in the chapters wherein he exposes the fallacies and the unconscious cant of the so-called "pacifists." Did this voluminous work contain nothing more than this analysis, or shall we say vivisection, of the most fallacious and dangerous doctrines that ever have menaced the very existence of the country, the book would be well worth its purchase price. The subjects for illustration have been well chosen and they are highly illuminating. The present war will be won mainly by artillery—an arm in which we are wofully deficient, as shown by the plate, page 104, which credits Russia with 6,000 field guns, Germany with 5,000, France with 4,800, Austria with 2,365, Japan with 1,250 and the United States—twice as rich as the next richest nation—with 634. The author shows in much detail how relatively weak is the United States navy compared with the vast and far-flung territory, coastline, wealth and population which it has to defend—to say nothing of the possible seeds of war which exist in the great national policies, such as the "Monroe Doctrine," the "Open Door" in China, Asiatic exclusion, and the preservation of the neutrality of the Panama Canal. Perhaps the most astonishing to the average reader of the illustrations will be one showing, diagramatically, a comparison of the casualties of Peace and War. From this we learn that the total number of killed in six wars, viz., our losses in the wars with Spain and Mexico, our Civil war casualties on the Federal side, the the English in the Boer war, the English and French in the Crimean war, and the Japanese killed in the Russo-Japanese war, together totaled 75,982, whereas the average annual number killed in the United States during peace is 79,000.

PERFUMES AND COSMETICS. Their Preparation and Manufacture. By George William Askinson, Dr.Chem. New York: The Norman W. Henley Publishing Company, 1915. 8vo.; 344 pp.; 32 engravings. Price, $5.

In this translation from the German the fascinating subject of perfumes is comprehensively presented by a manufacturing chemist. A brief history of perfumery and a general discussion of aromatic substances fitly leads into the more practical considerations of the employment of vegetable and animal substances and of chemical products in the manufacture of perfumes. The methods and apparatus employed in the extraction of odors are carefully explained and described. Among other chapters worthy of especial note are those on synthetic products, the classification of odors, fumigating pastils, pencils, and powders, and the antiseptic and therapeutic value of perfumes according to the evidence of manufacturers and bacteriologists. Of course a very large portion of the space is devoted to formulæ and directions. Cosmetics, dentifrices and other toilet preparations receive an adequate share of attention. The work may be accepted with confidence, and many of its products are very easily prepared.

THE OFFICIAL GOOD ROADS YEAR BOOK OF THE UNITED STATES. Washington, 1915. Colorado Building.

The Good Roads Year Book is an excellent compendium of laws, technical improvements made in the development of good roads, financial considerations governing the building of good roads, and the like. An excellent article is that on road systems of foreign countries, giving very tersely the road mileage of each country, and the cost of maintenance per mile. How little or how great is the interest of the individual states of the union in good roads is exhibited by a consideration of State legislation. A good digest of convict labor laws shows how far convicts may be employed on roads. The principal types of roads are described in a good article on the subject. The State funds available for road work are carefully tabulated. Taken as a whole, the book gives one an excellent idea of the good roads movement in this country.

THE SECRET OF THE UNIVERSE. By Eugene Miller. Topeka, Kansas: Crane & Co., 1915. 8vo.; 255 pp. Price, $1.60.

When we approach that borderland between the universe of things and the universe of thoughts, it is strange how slight an argument will sway one man, and how weighty a consideration may fail to convince another. For more than 150 pages Mr. Miller gives us an exceptionally good example of popular philosophical writing. Then, suddenly, he "lays down the proposition that nothing can either 'conform to law' or 'obey law' without knowing;" hence that the corpuscle, the unit of matter, is intelligent; in short, that it is the mental unit as well as the physical. We cannot accept his startling proposition as axiomatic—and he offers no proof of it as a general proposition—unless we wrench the word "intelligence" out of its accepted usage, in which case the whole argument is annulled. Once we accept the corpuscle as the unit of both matter and mind, however, the way is opened for a series of original and brilliant hypotheses giving a wide and not unattractive interpretation of natural phenomena, and particularly of the origin and nature of gravity. The chapter on heat, light, and electricity continues these bold speculations, and the sheer force of its heterodoxy may really illuminate a few dark places.

POCKET GUIDE TO PRINTING. Compiled by George Vickers. New York: Oswald Publishing Company, 1915. 16mo.; 46 pp.; illustrated. Price, 50 cents.

THE AMERICAN HANDBOOK OF PRINTING. Containing in brief and simple style something about every department of the Art and Business of Printing. New York: Oswald Publishing Company, 1913. 8vo.; 300 pp.; illustrated. Price, $2.15.

The author, the advertisement writer, the business man—anyone, in short, who contracts for printing or furnishes material for setting up—will find this compact little "Pocket Guide to Printing" very useful. It shows the standard type faces, gives the old and the new size-names, explains proof-reader's marks, and lists paper sizes and weights commonly stocked, together with a fund of miscellaneous information upon other details pertaining to the art of the printer and illustrator. The third edition of "The Handbook of Printing" has been subject to careful revision and to some measure of reconstruction. In its original form the handbook was intended as a short cut to a printing education. Its numerous sections take captions such as "Type Making," "Type Faces," "Proofreading," "Inks," and "Presses," and a rather unusual method is followed, in that each section first presents the historical side of its subject, and immediately follows with practical considerations. This plan has its distinct advantages. The work includes a color chart as a guide to the mixing and harmonizing of colors. The whole makes up a handy desk manual that will prove exceedingly helpful to the printer and the advertiser.

THE FOUNDATIONS OF STRATEGY. By Capt. H. M. Johnstone, Military Lecturer to Edinburgh University. New York: The Macmillan Company, 1914. Price, $1.60.

Capt. Johnstone has written both a timely and an instructive book. Using the campaigns of the last hundred years as a basis of discussion, he gives us a clear insight into the manner in which great generals conduct their operations. Capt. Johnstone is evidently a believer in the principles followed in the present campaign, a believer, in other words, in the "full strength" idea that is now applied on so magnificent a scale in Europe. For all that the book was written without any reference whatever to the present campaign in Europe. Some excellent maps, very clear and large, simplify the readers' task of following the author's explanations.

WETTERKUNDE FÜR DEN WASSERSPORT. Von Dr. E. Mylius. Berlin: Verlag Dr. Wedekind & Co., 1914. 8vo.; 108 pp.; 21 plates. (Yacht-Bibliothek herausgegeben von der Redaktion der Zeitschrift "Die Yacht," Band VIII.)

The author of this unique book is not a professional meteorologist, but an enthusiastic yachtsman who has become "weather-wise" through many years' careful observation of winds and skies, supplemented by a study of meteorological text-books. Persons who lead an out-of-door life usually acquire more or less skill in predicting weather changes a few hours in advance—and it is such forecasts of short range that are useful to the yachtsman—but very few take the trouble to formulate their knowledge so that it may be readily imparted to others. Dr. Mylius has not only set down in writing the results of his observations, but he has produced several hundreds of drawings of the sky, and noted in connection with them the antecedent and subsequent weather. A selection of twenty-one of these drawings appears in his book, all of them typical and true to life. This is probably the best feature of the work. The author begins with a sketch of the general subject of winds and weather in relation to barometric conditions (cyclones and anti-cyclones), gives a description of cloud forms, and tells all that the yachtsman needs to know about weather maps and official weather forecasts and warnings. He points out the fact that the maps and forecasts have their limitations from the sailor's point of view; they are not always promptly accessible, and in any case he is mainly interested in weather changes of a local and rapid character. The scope of the book is indicated by the following chapter-heads: 1. Origin of the weather in western Europe. 2. Weather maps available for our use. 3. Personal observations. 4. Weather changes from good to bad. 5. Weather changes from bad to good. 6. Squalls and thunderstorms. 7. Waterspouts. 8. Calms and wind-shifts. 9. Wind direction and force. 10. Stormy weather and storm warnings. 11. Storm signals. 12. Rainy weather. 13. Currents in the Baltic and adjacent waters. 14. Waves. The *novel* portions of this book are little less useful to the American than to the German yachtsman; for information concerning weather maps and the like the American would naturally consult cis-Atlantic publications.

LEGAL NOTICES

PATENTS

If you have an invention which you wish to patent you can write fully and freely to Munn & Co. for advice in regard to the best way of obtaining protection. Please send sketches or a model of your invention and a description of the device, explaining its operation.

All communications are strictly confidential. Our vast practice, extending over a period of more than sixty years, enables us in many cases to advise in regard to patentability without any expense to the client. Our Hand Book on Patents is sent free on request. This explains our methods, terms, etc., in regard to PATENTS, TRADE MARKS, FOREIGN PATENTS, etc.

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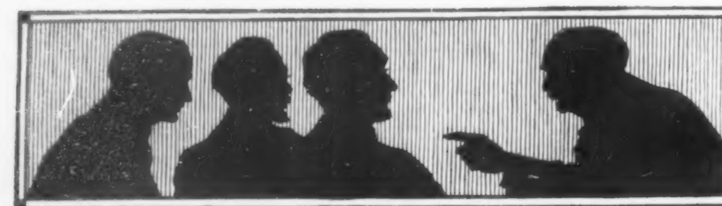

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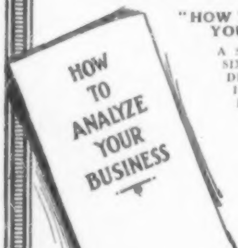

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In other words, with Bell's telephone the sound waves themselves generate the electric impulses, which are hence extremely faint. With the Berliner telephone the sound waves actuate an electric valve, so to speak, and permit variations in a current of any desired strength. All that now remains of the original Bell telephone is the receiver, which is still in essence what he made it.

In Gray's caveat, which he unfortunately filed in the Patent Office too late, it is pointed out that the variations of the current may be produced by causing the vibrations of the diaphragm to vary the resistance of the circuits. This is really the beginning of the microphone transmitter.

Herbert N. Casson, in his "History of the Telephone," summarizes transmitter development thus:

"From first to last the transmitter has been the product of several minds. Its basic idea is the varying of the electric current by varying the pressure between two points. Bell unquestionably suggested it in his famous patent when he wrote of 'increasing and diminishing the resistance.' Berliner was the first actually to construct one. Edison greatly improved it by using soft carbon instead of a steel point. A Kentucky professor, David E. Hughes, started a new line of development by adapting a telephone into a microphone, a fantastic little instrument that would detect the noise made by a fly when walking across a table. Francis Blake of Boston changed the microphone into a practical transmitter. The Rev. Henry Hunnings, an English clergyman, hit upon the happy idea of using carbon in the form of small granules. And one of the Bell experts, named White, improved the Hunning transmitter into its present shape. Both transmitter and receiver seem now to be as complete an artificial tongue and ear as human ingenuity can make them. They have persistently grown more elaborate, until to-day a telephone set as it stands on a desk, contains as many as 130 separate pieces, as well as a saltspoonful of glistening granules of carbon."

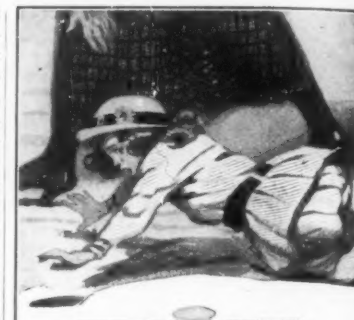
Such men as Carty, Scribner, and Dean have brought the telephone to its present perfection. The one man who did most to create the switchboard is Charles E. Scribner. Of the nine thousand switchboard patents granted, Scribner holds six hundred or more. It was he who devised the first jack-knife switch in 1878, although the first modern multiple switchboard was proposed by L. B. Firman in 1879. Joseph O'Connel of Chicago in 1887 conceived the use of tiny electric lights as signals. In 1901 J. J. Carty invented the bridging bell, a method of putting four houses on a single wire, with a different signal for each house, thus realizing the party line in a practical way. The common battery system was introduced in 1896.

One of the most remarkable improvements in telephone apparatus which has been made within recent years is the "Load Coil" of Prof. M. I. Pupin, brought out about 1899. Pupin introduced coils in telephone circuits in order to obviate the bad effects of capacity, by increasing the self-induction. Thanks to this invention, it is possible to communicate over extremely long distances. Indeed in 1915, telephonic communication was established between New York and San Francisco with the aid of the Pupin coils. The economic effect of the invention is remarkable. Thin wires were made to work as effectively as thick wires, thereby saving millions of dollars in copper.

An interesting type of speech transmitter is that dependent upon the variations in a beam of radiant heat or light. Such apparatus are designed on the principle that selenium varies in electrical resistance when exposed to light or radiant heat. Experiments were made by Bell and Sumner Painter over thirty years ago, which proved that if a beam of light be reflected from a mirror to a bar of selenium which is in the circuit of a telephone and battery, the telephone will repeat words spoken to the mirror. Perhaps the most efficient type of photophone, as this instrument came to be called, was that developed by Ernest Ruhmer of Berlin, about ten years ago.

The Automatic Telephone.

The history of the first creation and subsequent development of automatic telephone equipment, by which connections between the various stations in a system are established through mechanical means,



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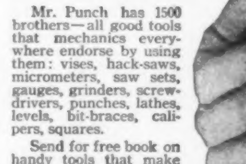

instead of by a human operator, covers a period of approximately twenty-seven years, for while as early as 1879 there were attempts made to solve the problems of mechanical switching, these were abortive and led to nothing tangible. It was on March 12th, 1889, that Mr. Almon B. Strowger, at that time an undertaker in Kansas City, Mo., filed his first application for a patent covering a system of automatic telephony, and although the equipment there described was very crude, it embodied many of the essential principles found in the apparatus to-day.

The first specifications cover the terminating of subscribers' lines on contacts arranged in layers or levels on the inside of a section of a cylinder, and of connecting them with other lines by means of wipers fixed on a shaft having a vertical and rotary movement. The first mechanism required seven wires from each station to the central office mechanism, which was controlled by means of push buttons mounted on the telephone. Pressing one of these buttons the proper number of times sent current to a magnet which lifted the wiper shaft to the desired level. Pressing a second button sent current to a second magnet, which caused the shaft to revolve, bringing the wipers into contact with the line leading to the called telephone. A third button was used to ring the bell, and at the end of the conversation, the connection was released by pressing a fourth button, which caused a magnet to withdraw the detents which held the shaft in position. Strowger was not an electrical expert. While his invention was extremely crude and impractical for actual service, it contained many possibilities of development. Mr. Alexander E. Keith, an electrical engineer, became interested in the subject. Under his guidance the improvement of the apparatus began at once, and has continued uninterruptedly for the past twenty-five years.

A review of the history of the adoption of automatic equipment shows that the first public exchange was installed in La Porte, Ind., in 1892. Since that date some one hundred and fifty other exchanges have been installed in the United States, especially in the Central and Western States.

Facsimile Telegraphy and Phototelegraphy.

Telautography, or telegraphic transmission of a facsimile of handwriting, or drawings, and phototelegraphy, or telegraphic reproduction by a receiver of a picture sent by a transmitter are in their present states the slow results of the experiments of many inventors during a long period of years. The first device of all, a copying machine intended especially for transmitting print, was invented by a Scotchman, Alexander Bain, who obtained a patent for it in 1843. In this each letter was formed by a number of lines, each line being transmitted by a special wire. The lines were produced by a comb containing insulated metal points, which glided over the type to be transmitted. A similar comb at the receiving end reproduced the lines on a chemically prepared paper. Bain proposed to copy the type with one metal point alone, omitting the comb and transmitting one line after another, but the patent does not make clear how the lines were put together. Bain's method was later taken up and improved by Bonelli, who exhibited his apparatus at the London Exposition of 1862. The next and more practical copying machine was that of Bakewell, who in 1847 transmitted handwriting. Metal foil inscribed with insulating ink was wrapped around a cylinder, the rotation of which by clockwork caused a metal style to glide over the foil. The same conditions existed at the receiving cylinder, except that chemically prepared paper was substituted for the foil. With each rotation the styles shifted slightly toward the axes of the cylinders, and an effort was made to keep the rotation synchronous.

All succeeding copying processes rest upon either Bain's or Bakewell's theories, the first making use of the oscillation of a pendulum, the other employing the rotation of a cylinder. Hipp's invention (1851), although of little practical value, introduced a new element, an electro-magnetic receiving device to replace the electrochemical one. Every electric impulse from the transmitter brought a small electromagnet into action, which caused an automatic pen to be pressed against ordinary writing paper. Caselli's "Pantelegraph" (1855) had reciprocating action, metal foil, and better synchronous movement. This was the first device to come into actual service, being used for a time between Paris and some French provincial cities. The Alsatian, Meyer (about 1864), brought out an apparatus with electromagnetic receiver, the novelty being in the helix, which takes the place of the receiving metal style. This was the first electro-magnetic copying telegraph to come into practical use. Gérard (1865) devised a metal style that moved in spiral lines like the needle of a gramophone, but the idea led to no result. Also in 1865 Hubert, a Frenchman, proposed replacing the insulating marking on the foil by heavy marking forming a kind of relief. This idea was developed later by others. Lénoir, who in 1867 proposed an original method of synchronism, is said to be the first to suggest transmitting photographs by the telautograph, after reduction to black and white. He was also the first to lay carbon paper upon white in a receiver. In 1868 D'Arlincourt produced an improved synchronism in which tuning-forks were employed for the first time in a telautograph. His theory is largely used at the present time. In the seventies, Sawyer, an American, introduced the pressing of the paper containing the writing to be transmitted on a zinc plate, thus making a printing plate, also a method of writing in relief or embossed lines for the transmitter. Relief writing was furthed developed by Edison in the early eighties, and by Denison in the middle of the eighties. De Hondt (1874) obtained synchronism by using a special line aided by a vibrating pole-changer, and Sheehy (1893) by a special line aided by alternating current motors. Bain's idea in the formation of letters was revived by Parcelle (1882) and Brooks (1884), who used alternating currents of different frequencies. Hummel's telediagraph and the electrograph of Dunlany, Palmer and Mills, which appeared at the close of the last century, are copying telegraphs with electro-magnetic receivers.

The telautograph has also proved capable of working in connection with wireless telegraphy. The idea was first brought out in the patents of Küster (1898), and Greville-Williams (1899) and was further developed by Braun (1903), Pansa (1904), Garcia (1908), and Knudsen (1909). In all of these apparatus the conductive part of the transmitting foil closes the primary current of a Ruhmkorff coil by the aid of which electric waves are sent out. At the receiving end a coherer closes a local current during the arrival of the waves from the transmitter. Among the telautographs based upon this method which have had practical demonstration are those of Berjonneau (1907)), Thorne Baker (1909), and Korn.

In another form, the telautograph, instead of copying the original in fine lines at the receiver, makes a recording pen follow the movements of a pencil writing at the transmitter. The idea is that the movement of the point of the pencil on a level surface is made up of two components which can be sent separately by quantitative or pulsatory currents and recombined at the receiver. The first person to suggest transmitting handwriting in this way was the Englishman Jones (1855); then came Lacoine (1857) and Bienaymé (1858), who proposed a separation by rectangular co-ordinates. In 1878 Cowper, an Englishman, made the first actual long-distance writer working on the two component principle, using in it quantitative transmission. In 1881 Jordery, a Frenchman, demonstrated a model at Paris. In 1885, Robertson, an American, brought out a device which is a development of Cowper's ideas. In 1886 Höpfner suggested separation by polar co-ordinates. O'Brien's method (1888) was very much like that of Elisha Gray, who in the same year brought out his first apparatus.

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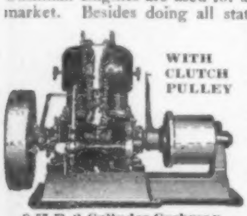

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Gray's tranmission was by pulsatory current; the receiver had two pairs of electromagnets, the pairs differing in the exciting polarity. Gray's ideas were further developed by Tiffany (1895) and MacPherson (1897). On very much the same principle was Ritchie's "telewriter" (1899). Tiffany and Ritchie used quantitative transmission. In 1902 the "Graz annagraph," somewhat similar to Gray's, but with a photographic reproduction in a receiver, was brought out by a company at Dresden. Cerebotani (1904) used a method by pulsatory, also very similar to Gray's.

The development of the copying telegraph into a photographic recorder was a very natural one. Little (1867) was the first to suggest a photographic recording process for telegraphic signs; Dillon (1879) first proposed a photographic receiver for a telautograph; Cellino (about 1901), like Dillon, used a mirror galvanometer in the receiver. The next advance over this was the transmitting of photographs. Four methods can be used in transmitting photographs by telegraph, which, in order of practicability, are: 1, telautographic transmission; 2, by the aid of selenium in the transmitter, with use, in some cases, of progressive relays of light and intermediate *clichés;* 3, a relief method; 4, what may be called the statistical method. In the telautographic process the photograph to be transmitted is first changed to black and white by means of a glass screen. Carbonnelli, a Belgian, who brought out (1906) an apparatus with a telephone diaphragm instead of a magnetic relay in the receiver, in the end confined himself to reproducing black and white pictures. Berjonneau and Thorne Baker (the telectrograph with electrolytic apparatus in receiver), both brought out methods for reproducing photographs.

The second method is based on the sensitiveness to light of selenium, a discovery made in 1873 by the English engineers, Willoughby, Smith and May. Senlecq (1877), a Frenchman, suggested applying the varying conductivity of selenium under changing conditions of light to the telegraphic transmission of a photograph, which he proposed to reproduce as a fixed, visible object. Bidwell, an Englishman, in 1881, suggested a better method in which he used the changing resistance of selenium to give the values of the picture in the transmitter and electro-chemical reproduction. The selenium cell was improved, especially by Giltay of Delft, and Korn (1902) brought out a further photographic method. In this a bright light concentrated on a portion of a transparent film attached to a glass cylinder is thrown from a totally reflecting prism within the cylinder upon a selenium cell at end of cylinder. Rapid changes of current are received by a galvanometer at the receiver, and the developed picture consists of a number of parallel lines varying in tone. Frikart (1906) proposed transmitting photographs by wireless.

In the relief method variations of light and shade are expressed by the heights and depths of a relief print which are traversed by a style. By the aid of resistance devices these differences produce variations of current. The method was first proposed in 1880 by Eaton, an American, who suggested a diaphragm carrying a spirally moving style in the transmitter and one carrying a pen in the receiver; the latter was to be pressed by a magnet upon the paper and the picture produced in a spiral line. An apparatus with wax cylinder in transmitter and wax relief in receiver was devised by Amstutz about 1891; Kiselzka (1896) used a continuous current with variation of length of the closing of the current. The longer the closure the more light fell upon the photographic plate of the receiver. In 1903 Sémat proposed a vibrating telephone diaphragm to cause fluctuations of current. In 1907 Bélin a Frenchman, used an oscillograph in the receiver, its movement regulating the light falling upon the photographic film. Senlecq and Tival (1907) made some not very practicable suggestions as to the use of intermediate *clichés* (carbon or pigment prints), but the prin-

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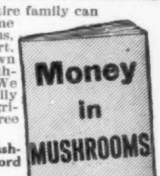

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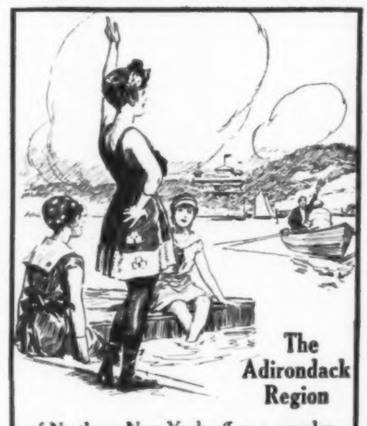

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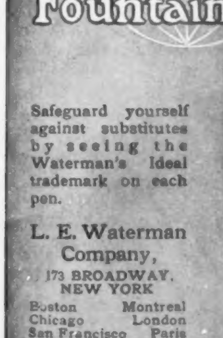

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ciple of the Adamian method (about 1907) of transmitting variations of tone by intermediate *clichés* has more value.

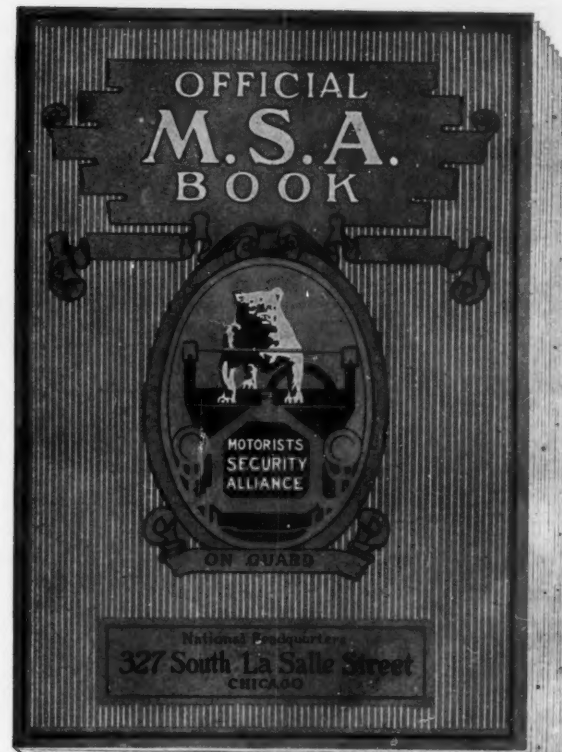
In the statistical method the picture is divided into a large number of small squares, the values of which are estimated and sent as numbers or combinations of numbers in an ordinary telegram, which is then traced out on a correspondingly ruled paper. Gras (1897) proposed sucn a method for simple outlines. The same idea was brought forward by Rickinson in 1889. In 1895 Willoughly obtained a patent for a somewhat improved invention. A further advance was made by Walter (1897), who sought to transmit half-tones. In 1904 Fortong combined this method with a form of intermediate *cliché*. In 1910 Stolfi and Bissiri made some practical experiments between Chicago and New York by a method similar in principle to Walter's.

When Prof. Heinrich Hertz, in 1887, at Karlsruhe, evolved his splendid experimental proof of the Maxwellian theory of light as an electromagnetic wave phenomenon it would have been indeed a wild dreamer who could have foretold even present-day uses of wireless telegraphy. But an inkling of the future crept out when, two years later, Elihu Thomson suggested that the Hertzian waves might prove valuable for *signaling* through fogs or material objects which could not be penetrated by the shorter waves of light. This idea of Hertzian wave telegraphy was not, however, productive of immediate results, for the inception of radiotelegraphy did not occur until six years later.

In 1890 Edouard Branly's investigations at Paris resulted in the production of delicate instruments which had the property of indicating the presence of Hertzian waves. These operated virtually by closing up the tiny gaps between particles of a pulverized metallic mass, upon the arrival of waves, and so thereafter received the name "coherer." A few years later, in England, Sir Oliver Lodge repeated the experiments of Hertz on a larger scale, using the coherer instead of Hertz's spark-gap resonator as a responding device. In this work fairly large distances, at least as compared to the earlier experiments, were traversed by the waves in passing from sender to receiver; it appears that the purpose was not telegraphy, however, but rather a further confirmation of Maxwell's theory.

In 1895, Prof. Popoff of Kronstadt, Russia, erected an apparatus for the purpose of observing lightning, and in so doing produced the nearest approach to a usable wireless telegraph receiver that had been built up to that time. Modifying the Branly coherer and combining with it a relay, recorder and tapping mechanism he secured a receiver which would mark upon a tape the time of each distant lightning flash. In addition, his apparatus would automatically prepare itself to record the next flash, by tapping the coherer gently and so breaking apart the particles which had been brought together in responding to the lightning discharge just received. Further, his arrangement included an elevated conductor for the purpose of collecting the energy of electromagnetic waves due to lightning, and a ground connection. It is interesting that an essential duplicate of this receiver as used twenty years ago is now utilized by one of the large power houses in New York to indicate the approach of thunderstorms and so to give warning that preparation must be made to meet an increased lighting load throughout the city.

The very next year, 1896, Guglielmo Marconi demonstrated in England the first real radio telegraph system which had ever been produced. By combining the Morse key with a more powerful form of Hertz transmitter, by perfecting the coherer of Branly, Lodge and Popoff, and by adding various new devices for protecting the instruments and preventing false operation, the pioneer invention was created. Although the various elements in rather crude form had been at hand for years, it required Marconi to correlate them so as to give the world an operable radiotelegraph. In the 1896 experimental messages were transmitted one and three quarter



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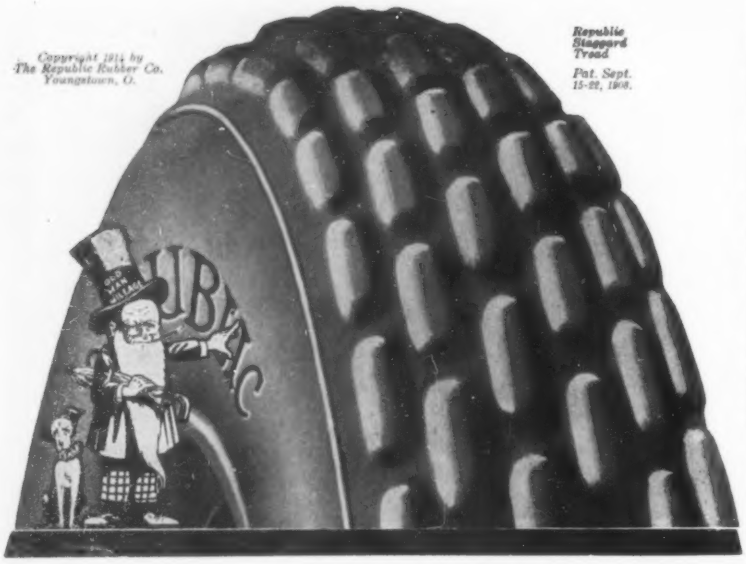

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miles across Salisbury Plain; early the next year the distance was increased to four miles, and soon, by using an earth connection with elevated aerial wires supported from kites and abandoning the parabolic reflectors, signaling was effected over nearly nine miles.

In 1897 Lodge began the application of his earlier work to actual wireless telegraphy, and on through 1898 produced a complete system which was characterized by excellent syntonization at both sender and receiver. By the insertion of inductance coils in the circuit between the elevated conductor and the earth he so greatly increased the persistence and definiteness of oscillation that sharp tuning of stations and consequently a considerable degree of freedom from interference was had. The same year, 1897, marked the entrance into the field of R. A. Fessenden, in the United States, and the beginning of the development of his system.

Fessenden's methods were especially notable because of his radical departures from the early art as practiced by Marconi. Instead of using the coherer, which was operated by the development of a single voltage, sufficiently great to cause partial amalgamation of the particles, Fessenden developed receivers in which the response was proportional to the total power being received from the transmitter at any instant. Again, instead of attempting to produce abrupt and rapidly decadent oscillations by sudden disruptive discharges of condensers, he directed his efforts toward more nearly or completely sustained waves, and even devised a method for their direct generation by means of a very high frequency alternator.

Marconi in 1898 worked out an arrangement of coupled circuits tuned to vibrate in unison both at sender and receiving station, and so made possible the transmission of large amounts of power without sacrificing sharpness of tuning. In this same year Ferdinand Braun, of Strassburg, Germany, worked out a somewhat similar arrangement for increasing power of radiation, but seems not to have included the essential of unison in vibration frequency of the various circuits.

The general trend of the art was toward erection of stations of higher output for signaling over greater distances; and on December 12th, 1901, Marconi succeeded in transmitting repetitions of the letter "S" (groups of three short impulses in the Morse code) across the Atlantic from Poldhu, in Cornwall, to St. John's, Newfoundland. About this same time activity and interest in wireless began to grow rapidly. Lee de Forest, in the United States, commenced work on arrangements of apparatus which were later embodied in the equipment supplied to many vessels and shore stations. Fessenden was continuing the evolution of his persistent and continuous wave systems, and devised many specific forms of transmitter and receiver which later came into wide use. The liquid barretter (electrolytic detector) is a product of this period.

In 1903, when Marconi was able to transmit actual messages entirely across the Atlantic at night, Valdemar Poulsen (the inventor of the telegraphone), in Denmark, devised a wireless transmitter comprising a direct current arc burning in hydrogen, which produced sustained waves and now forms the sending equipment of many powerful installations. It required about three years for the development of this arc oscillator to reach practicability; in the meantime, toward the end of 1905, Fessenden transmitted the first messages both ways between the United States and Great Britain, using his powerful musical toned spark stations near Boston and in Scotland.

In 1906 deForest commenced work on a development of the vacuum tube rectifier which Fleming applied to radiotelegraphy years before, and termed the new device an "audion." Outgrowths of this receiver are now proving useful as telephone amplifiers and very delicate wireless detectors, and are even used to produce waves for short distance transmission by radio. At Strassburg, Germany, during this period, Max Wien discovered some curious properties of transmitter circuits which were later involved in the Telefunken and Lepel impulse excitation systems.

In late 1907 Marconi opened a restricted public radio service between Glace Bay, Nova Scotia, and Clifden, Ireland, thus going into direct commercial competition with the Canadian cables for the first time. Less than a year later the Glace Bay "circuit" was offered for all classes of telegraph traffic, and it has remained in almost constant service since that time.

The first great life-saving feat to the credit of radio occurred on January 23rd, 1909, when the steamships "Republic" and "Florida" collided at sea. The "Republic" was able to secure assistance by wireless, and, though the vessel sank quickly, all her passengers were rescued. There have been many instances since then in which sinking or disabled ships have been able to gain help by sending out the radio distress signal, and the value of wireless equipment as insurance for vessels at sea has thus been clearly proved.

For the four years through 1914 radiotelegraphy had the normal growth of a young and valuable art; much progress in the detail of apparatus was made and a number of radical improvements brought forth. The Federal Government completed its powerful station at Arlington, Va., and worked in connection with the Eiffel Tower in a series of important experiments. The transatlantic stations at Tuckerton, N. J., and Hanover, Germany, nearly 4,000 miles apart, were put into communication early in 1914, so forming the first very long-distance link using the ingenious direct generation machines devised by Rudolf Goldschmidt. Transpacific commercial radio by the use of Poulsen arc generators has been in service several years, and last year a second wireless "line" between San Francisco and Honolulu was opened with Marconi spark transmitters.

The cutting of the German cable shortly after the opening of hostilities abroad last July gave a great impetus to transatlantic radio, and at this time both the Tuckerton-Hanover and Sayville-Berlin links are in operation. Various other uses of radio, such as the electrical location of enemy field wireless stations and communication with air vessels at moderately long distances, have been strongly emphasized by the war, and we may expect in the not distant future many additional and valuable applications of this interesting mode of conveying intelligence.

The Development of Radiotelephony.

The transmission of vocal sounds by wireless, in radiotelephony, has not yet become of commercial importance. This branch of the radio art originated in America something over ten years ago, at the time when the principles of producing sustained waves and modifying them by the use of telephone transmitters were brought forth. The three main problems of radiotelephony have been to generate uniform radio-frequency alternating current, to modulate it in accordance with speech waves, and to interlink wireless and wire telephones by means of suitable relays. Each of these difficulties has been overcome to some extent, and among those who have contributed largely to practical progress are Fessenden in the United States, Colin and Jeance in France, Poulsen in Denmark, Majorana in Italy, various engineers of the Telefunken system in Germany, and Marconi in England.

Although imperfections and limitations in methods and apparatus used have prevented widespread adoption of radiotelephony, much can be expected from this art in the future. When reliable apparatus capable of talking over 100 miles of sea at any time can be secured, it seems probable that the steamship service will find use for speech signaling. And when instruments are finally produced of such size and efficiency that spans of 1,000 miles or so can be covered regularly, it is not difficult to see how great will be the value of radio as a trunk link in long distance telephony. With wireless "lines" between cities, the voice may be transmitted over a distortionless ether system which need not be charged as an investment, for which no depreciation allowances are necessary, and which nature herself maintains constantly in perfect working order.

The Patent Office and Invention Since 1845

(*Concluded from page 534.*)

shown by the large number of very important contributions she has devised in the last 35 years, and the increasing number of patents she has taken out in this country in recent years, now exceeding those applied for by any other foreign nation. To her sons is due the gas engine, the gasoline motor; the crude oil engine (Diesel motor); the automobile; the Welsbach lamp; the Tungsten lamp; the X-Ray machine; the utilization of blast furnace gases for operation of gas engines; the superheating of steam in locomotive practice, the synthesis of indigo; the contact method of making sulphuric acid, the Goldschmidt thermit process, and the innumerable and radical innovations in dye making, drugs, and chemicals.

An interesting confirmation of the changing character of our population may be made by comparing the names of inventors prominent in the earlier periods of the country's history with those which are found frequently scattered through the later additions of the Official Gazette. Fulton, Whittemore, Bigelow, Blanchard, Hoe, Campbell, Ames, Fairbanks, Howe, Colt, McCormick, etc., testify to the complete Anglo-Saxon predominance of former times, while such names as Bettendorf, Mergenthaler, Pupin, Tesla, Christensen, Doherty, Frasch, Gallagher, Conner, Monnot, Krakau, Mesta, Steinmetz, Sauveur, and Lindenthal, which are abundantly sprinkled among the names listed in recent Official Gazettes, offer proof of the leavening that is going on in all departments of American life.

Converting Night Into Day

(*Concluded from page 536.*)

during the late seventies. We have already referred to the so-called "incandescence-arc" lamps, which mark the offshooting of the incandescent lamp from its parent stem, the arc. Numerous attempts, some of them involving much ingenuity, were made to produce a successful lamp of the "incandescence-arc" type, and much money was sunk in valueless patents, as Dredge's classic tome, "Electrical Illumination," containing records of all these early patents, abundantly testifies. One lamp of this sort was De Moleyn's. It comprised a glass globe with plugged openings for connection to a vacuum pump; into the upper part of the globe a tube containing finely powdered carbon was sealed; a movable copper wire ran through this tube and protruded through the orifice at its lower end (inside of the globe), this orifice being exactly large enough to let the carbon dust trickle through slowly, forming an "incandescence-arc" between the copper wire and a platinum spiral that came up through the bottom of the globe.

J. W. Starr of Cincinnati, Ohio (a *protégé* of George Peabody, the philanthropist), tackled in grim earnest the job of inventing a practical incandescent electric lamp, and his efforts resulted in the so-called Starr-King lamp, patented in 1845, when its inventor was only twenty-three years old. Two years later—in the very year, by a singular coincidence, that Edison was born—the ill-starred Starr had worked and worried himself to death; had he lived to complete his experimenting, the successful incandescent lamp might conceivably have been brought forth some thirty years sooner than it actually was. Starr's lamp had a Torricellian vacuum, the vacuous chamber, like that in a barometer tube, being formed by the inversion of a glass tube containing mercury; the "filament" consisted of a stick of retort carbon about one eighth inch square in cross-section. The lamp gave a good, bright light when new, but blackened rather quickly, and was further handicapped by the lack of a cheap, practical system of electricity supply.

Incidentally, we are told that the first electrolier for incandescent lamps was made by Pearce of Boston, about 1842, on George Peabody's order, and was used to interest capital in Starr's inventions. Electroliers were also shown in England by Starr and Faraday.

A period of comparative stagnation in electric-light development, relieved to be sure by Planté's invention of the storage-battery (1860), ensues for the next twenty-five years, but with the seventies the flood-tide of modern discovery sets in. In 1870, three years after Faraday's death, Z. T. Gramme received a patent on a really practical direct-current dynamo. In 1875 the Sprengel vacuum pump, which became almost immediately an important factor in solving the problem of successful incandescent lamp manufacture, was introduced. In the following year Lieut. Jablochkoff patented his famous "candle," consisting essentially of two vertical sticks of carbon separated by a thin fusible insulating barrier, across the top of which an electric arc played. The rated life of the various types of Jablochkoff candle, which worked on a voltage of about 42, varied from 1 hour and 20 minutes to 3 hours and 20 minutes. Thousands of these candles were sold, although comparatively few found their way to the United States, before they were driven out by the more modern arcs and incandescent lamps.

Meanwhile Charles F. Brush and Thomas A. Edison had applied themselves to the stupendous and hitherto unsolved problem of utilizing electricity for general lighting purposes. Brush exhibited his first arc lamp of the wonderfully simple and successful ring-clutch type in 1877, and in the next year produced that other indispensable feature of his system, the series arc dynamo, and started arc lighting campaigns all over the world. Four years later Brush arc lights, made in Cleveland, were in nightly operation in Shanghai and Tokyo.

The history of the arc seems incomplete without mentioning the early work of Elihu Thomson. He invented a generator, absolutely unique. In connection with it he developed the magnetic blowout, which has been extensively employed ever since in controlled, lightning arresters and circuit breakers. He also invented an arc lamp and regulator. Indeed, the Thomson-Houston and Brush arc systems were active competitors.

In 1879 several inventors were working on the incandescent lamp problem, among them Sawyer and Man, who experimented extensively with filaments of carbonized paper; Lane-Fox, who used vegetable fibers; Swan, who in February of that year publicly exhibited a lamp with a filament of parchmentized tread; Weston who worked even at that early date with squirted and cut nitrocellulose, and Edison, who tried out substances far too numerous to mention here, but including platinum, lamp-black, tar and paper. One might, perhaps, think that the failures of De Changy, De Moleyn, Starr, and others would have had a discouraging influence on these inventors in the late seventies, but they regarded them merely as light-houses, showing what to avoid. Edison's famous exhibition of his complete incandescent lighting system, when the laboratory grounds were illuminated by seven hundred lamps, took place late in December, 1879, and attracted prominent visitors from all over the country. This may be considered the crowning, as it was the closing, event in the progress of illumination during the eighth decade.

Development during the years 1880 to 1889 was rapid and important. Lamp costs were brought down, as ways of simplifying and standardizing lamp parts were discovered. The price of arc light carbons was gradually reduced from $240 per thousand to about $10 per thousand. The art of "pasting" carbon filaments to the lead wires was discovered; previously, the filaments had to be attached by expensive mechanical devices, such as tiny bolts, nuts, washers, sleeves, and clamps.

The three-wire system of direct-current distribution was first put into commercial operation in 1883 at Sunbury, Pa. Who invented it is almost impossible to determine. Edison certainly developed it as part of his commercial system of incandescent lighting, and so did Edward Weston, long before, in the days when he first

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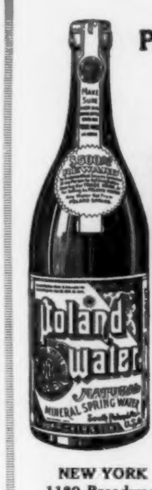

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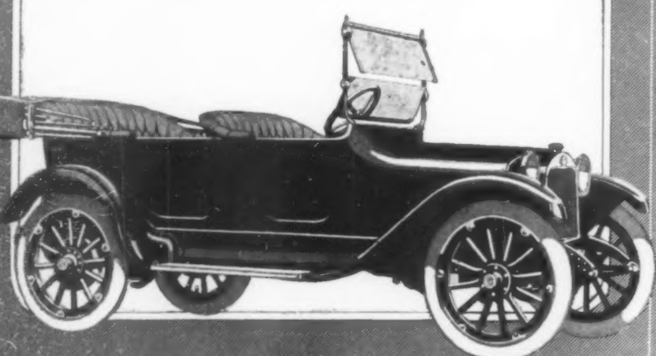

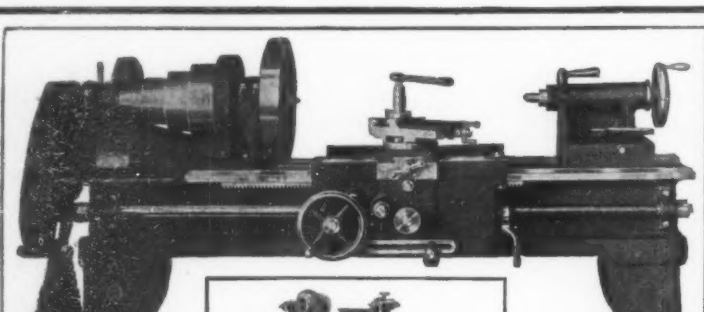

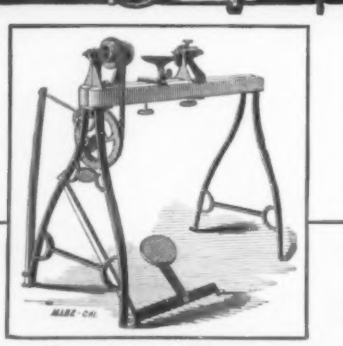

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used the dynamo in electroplating on a large scale. In 1866 Mr. George Westinghouse installed the first regular alternating-current central station in America at Buffalo, N. Y., and during the entire ten years under consideration the central station industry was rapidly extending its roots and branches. By 1890 electric lamps—incandescent and arc—had made their way into every civilized country.

The nineties, too, were prolific of discoveries. In 1891 the cellulose or "squirt" process of making carbon filaments was commercially introduced. Two years later the cellulose filament generally supplanted the bamboo. In 1895 came the "chemical exhaust" for incandescent lamps, which improved their average quality, at the same time reducing their cost, and was largely responsible for the reduction in price of carbon lamps in 1895 from 32½ cents to 20 cents each. Meanwhile the process of "treating" filaments in hydrocarbon vapor, rendering them more uniform and improving their radiating properties, had been introduced, although that, too, had been discovered very early by Edward Weston.

As experts and facilities for research multiplied, improvements, first of minor importance, but more recently of a revolutionary nature, were evolved. The substitution of molded bulbs for "free-blown" bulbs, about 1892, and the invention of the turn-down lamp by Phelps in 1898, belong, relatively speaking, in the category of minor improvements. The first indication to the world that the metal-filament lamp might eventually supersede the carbon came about 1898, when Dr. Welsbach produced his first osmium filament lamp. Curiously enough, tungsten had been tried for filaments as early as 1889 by Lodyguine and Tibbets, but unsuccessfully, as these workers did not realize the importance of having the metal extremely pure.

The mercury arc lamp was originated by Arons in 1892 and later developed to a point of greater commercial practicality by Cooper Hewitt.

The invention of the inclosed arc lamp in a practical form was announced at an electrical convention in 1894, when L. B. Marks described the first inclosed arc lamp embodying the points that made it, for a period of about ten years, the favorite unit for high candle-power lighting in America.

In 1899 the Bremer flame arc was announced, and in the following year Bremer exhibited at the Paris Exposition a model having four impregnated carbons, so arranged that the light produced was reflected downward. The modern "yellow-flamer," with carbons impregnated with calcium compounds, is an outgrowth of Bremer's lamp. Flame carbons giving light of various colors have also been developed, such as those containing salts of strontium, giving a pink light, or those of barium, which give a white light. The best-known of all the luminous arcs, however, is Steinmetz's invention, the "Magnetite," the electrodes of which are composed of metals and metallic oxides, without any carbon "body." It is essentially a direct-current lamp.

The discovery of ductile tantalum came from a German laboratory in 1901, and the first experimentally successful tantalum lamp was constructed a year or so later, although tantalum lamps were not in a condition to be placed on the market for several years more.

Meanwhile, in 1905, the "metallized" carbon lamp, in connection with which notable work was done by J. W. Howell in one of the laboratories of the largest American electrical manufacturer, made its appearance and served as a sort of stepping-stone to the lamps of still higher efficiency that were about to make their appearance.

In 1907 came the pressed-filament tungsten lamp, for which we are indebted in a great measure to two European inventors, Just and Hanaman. This lamp, under the hands of such men as Dr. W. D. Coolidge, Dr. A. Pacz, and a host of other experts, has gradually evolved into the strong, durable, cheap drawn-wire lamp of to-day.

The very newest line of development, due in the first place largely to Langmuir and Orange, working under the direction of Dr. W. R. Whitney in the Research Laboratory of the General Electric Company, has given us non-vacuum incandescent lamps with efficiencies deemed utterly impossible a few years ago. Some of these big lamps, the bulbs of which are filled with inert gases, actually take less than half a watt per candle. They are giving the arc lamps, particularly of the old open and inclosed types, a hard race just at present.

Although there have been wonderful accomplishments in arc and incandescent lighting during the past century, yet we all share more or less the attitude of Mr. Edison, who, in the course of a conversation with the writer, remarked: "I don't like to go into things connected with ancient history, or the dead past—what I am interested in is the future; in what is going to happen to-morrow." And assuredly there is much to be done. Scientists find that the most efficient arc and incandescent lamps of to-day waste something like 85 per cent of their incident energy in other forms than light—from an efficiency standpoint they are outshone by the common firefly. So the curtain of mystery still veils the lamps of our descendants.

Some Personal Recollections

(*Concluded from page 537.*)

a lightning flash. In an instant I saw it all, and I drew with a stick on the sand the diagrams which were illustrated in my fundamental patents of May, 1888, and which Szigety understood perfectly.

It is extremely difficult for me to put this experience before the reader in its true light and significance for it is so altogether extraordinary. When an idea presents itself it is, as a rule, crude and imperfect. Birth, growth and development are phases normal and natural. It was different with my invention. In the very moment I became conscious of it, I saw it fully developed and perfected. Then again, a theory, however plausible, must usually be confirmed by experiment. Not so the one I had formulated. It was being daily demonstrated every dynamo and motor was absolute proof of its soundness. The effect on me was indescribable. My imaginings were equivalent to realities. I had carried out what I had undertaken and pictured myself achieving wealth and fame. But more than all this was to me the revelation that I was an inventor. This was the one thing I wanted to be. Archimedes was my ideal. I admired the works of artists, but to my mind, they were only shadows and semblances. The inventor, I thought, gives to the world creations which are palpable, which live and work.

The telephone installation was now completed and in the spring of 1882 an offer was made me to go to Paris, which I accepted eagerly. Here I met a number of Americans whom I befriended and to whom I talked of my invention, and one of them, Mr. D. Cunningham, proposed to form a company for exploitation. This might have been done had not my duties called me to Strasburg, Alsace. It was in this city that I constructed my first motor. I had brought some material from Paris, and a disk of iron with bearings was made for me in a mechanical shop close to the railroad station in which I was installing the light and power plant. It was a crude apparatus, but afforded me the supreme satisfaction of seeing, for the first time, rotation affected by alternating currents without commutator. I repeated the experiment with my assistant twice in the summer of 1883. My intercourse with Americans had directed my attention to the practical introduction and I endeavored to secure capital, but was unsuccessful in this attempt and returned to Paris early in 1884. Here, too, I made several ineffectual efforts, and finally resolved to go to America, where I arrived in the summer of 1884. By a previous understanding I entered the Edison Machine Works, where I undertook the design of dynamos and motors. For nine months my regular hours were from 10:30 A. M. till 5 A. M. the next day. All this time I was getting

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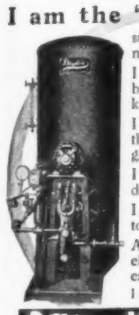

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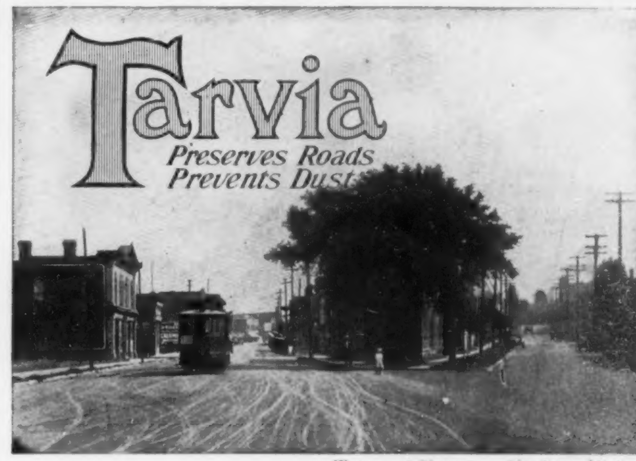
more and more anxious about the invention and was making up my mind to place it before Edison. I still remember an odd incident in this connection. One day in the latter part of 1884 Mr. Bachelor, the manager of the works, took me to Coney Island, where we met Edison in company with his former wife. The moment that I was waiting for was propitious, and I was just about to speak, when a horrible looking tramp took hold of Edison and drew him away, preventing me from carrying out my intention. Early in 1885 people approached me with a proposition to develop an arc light system and to form a company under my name. I signed the contract, and a year and a half later I was free and in a position to devote myself to the practical development of my discovery. I found financial support, and in April, 1887, a company was organized for the purpose, and what has followed since is well known.

A few words should be said in regard to the various claims for anticipation which were made upon the issuance of my patents in 1888, and in numerous suits conducted subsequently. There were three contestants for the honor, Ferraris, Schallenberger and Cabanellas. All three succumbed to grief. The opponents of my patents advanced the Ferraris claim very strongly, but any one who will peruse his little Italian pamphlet, which appeared in the spring of 1888, and compare it with the patent record filed by me seven months before, and with my paper before the American Institute of Electrical Engineers, will have no difficulty in reaching a conclusion. Irrespective of being behind me in time, Prof. Ferraris's publication concerned only my split-phase motor, and in an application for a patent by him priority was awarded to me. He never suggested any of the essential practical features which constitute my system, and in regard to the split-phase motor he was very decided in his opinion that it was of no value. Both Ferraris and Schallenberger discovered the rotation accidentally while working with a Gaullard and Gibbs transformer, and had difficulty in explaining the actions. Neither of them produced a rotating field motor like mine, nor were their theories the same as my own. As to Cabanellas, the only reason for his claim is an abandoned and defective technical document. Some over-zealous friends have interpreted a United States patent granted to Bradley as a contemporary record, but there is no foundation whatever for such a claim. The original application only described a generator with two circuits which were provided for the sole purpose of increasing the output. There was not much novelty in the idea, since a number of such machines existed at that time. To say that these machines were anticipations of my rotary transformer is wholly unjustified. They might have served as one of the elements in my system of transformation, but were nothing more than dynamos with two circuits constructed with other ends in view and in utter ignorance of the new and wonderful phenomena revealed through my discovery.

The Development of the Dye Industry

By M. L. Crossley, Sc.M., Ph.D., Associate Professor of Chemistry and Acting Head of the Department, Wesleyan University, Middletown, Conn.

AT this time when the entire public is in a feverish excitement over our newly realized dependence upon Germany for dyes and organic chemicals it is not amiss to call attention to the marvelous triumphs of chemists in the development of the dye industry. In spite of the fact that in our enormous coke production we have almost an unlimited supply of by-products suitable for the manufacture of dyes and organic chemicals, this industry has not made much progress in this country. This is not because of any inferiority on the part of American chemists to solve problems of this type, but rather, because circumstances have been more favorable for the development of other industries in America. The thorough organization of the dye industry abroad, backed by government support, made it impossible for our



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manufacturers to compete on a satisfactory basis.

The dye industry is by no means new. From the dawn of human intelligence the desire for adornment which could rival nature in beauty and variety of color has been evident. It is not improbable that Eve herself was impressed with the splendor of Mother Earth's marvelously beautiful colored garb and selected her own first cellulose gown after the same pattern. As far back in Antiquity as we can pierce we find evidence of colored fabrics having been worn and it is quite certain that the art of dyeing was practised by the Ancients with some skill and with no little pride. Wrappings of the mummies found in the tombs of Thebes, estimated to have been in use 4000 B. C., bear witness to the fact that indigo was used to dye muslin of unusually fine quality. Evidence of the continued use and appreciation of dyes by the ancients is not wanting. The book of Leviticus, supposedly written 1490 B. C., chapter 13, lends support to this view when it records the use of textile fabrics of beauty and strength. In the book of Genesis, written probably about 1723 B. C., we read, chapter 37, 31, "Now Israel loved Joseph more than all his children, because he was the son of his old age; and he made him a coat of many colors." Evidently a coat of many colors was a garment highly prized and therefore appropriate for the expression of Israel's love. Blue, purple, scarlet, and red seemed the popular colors. The book of Exodus, chapters 25, 26, 27 and 28, describes the specifications of the tabernacle which the Lord commanded Moses to build and therein it is prescribed that the tabernacle must have "ten curtains of fine twined linen, and blue, and purple, and scarlet with loops of blue," that the tent must have a covering of "ram's skin dyed red;" that there be provided a "veil of blue, and purple, and scarlet." That the tent have "an hanging for the door of blue, and purple and scarlet;" and also that "the gate of the court have an hanging of 20 cubits of blue, and purple, and scarlet." Frequent other references may be cited to show that, at least, the colors, blue, red, purple, and scarlet, were familiar to the ancients. The writings of Homer, Theophrastus, Discorides and the elder Pliny lead us to suspect that the art of dyeing was first practised by the Indians and that from them the Phoenicians acquired it and transferred it to the Egyptians from whom the Hebrews learned it. It is quite certain that the Egyptians practised the art of dyeing as early as 2500 B. C. The Chinese seem also to have prepared certain dyes and used them to dye silk at a very early period.

The popular demand for colored clothes has continued throughout the ages and come down to us as a genuine inheritance. To the Roman love for conquest we owe much for the freedom of the art of dyeing from the mysticism and secrecy of the East and for its dissemination throughout Europe. Rome was schooled in the art by the Jews and unintentionally passed it on to the peoples whom she conquered. Colors played no little part in the social and religious life of the people. Purple, in particular, was highly esteemed and set apart for the distinction of nobility. One writer says: "It is for this color the fasces and axes of Rome make way in the crowd; it is this that distinguishes the Senator from the man of equestrian rank; by persons arrayed in this color are prayers addressed to propitiate the gods; in every garment it sheds a luster, and in the triumphal vestment it is to be seen mingled with gold." Pliny is also authority for the information that this color was prized highly by the Romans. He says, "Pearls may be looked upon merely as an everlasting possession; of everlasting duration; they descend from man to man, and they are alienated from one to another just like landed estate, but the colors which are extracted from the Murex and Purpura fade from hour to hour, and yet luxury which had similarly acted as a mother to them has set upon them prices almost equal to those of pearls." The Murex and Purpura referred to are species of molluscs from which the purple dye used by the Romans was extracted, it requiring 12,000 molluscs to give 1.4 grammes of dye. The water of Tyre was

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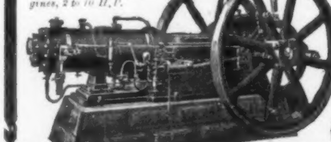

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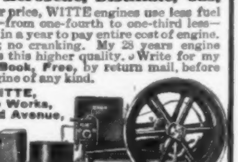

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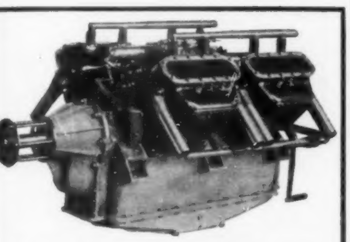

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famous for Murex and the dye was called Tyrian Purple. Cloth dyed with Tyrian Purple was extremely expensive. According to one writer of the first century, a pound of twice-dyed Tyrian Purple could not be purchased for less than 1,000 denarii or approximately $170 in American money.

The first period in the evolution of the dye industry witnessed chiefly the development of the art of applying natural dyes of animal and vegetable origin to different fibers. The ancients made woven fabrics of wool, silk, linen, and cotton with a considerable degree of perfection. On these they endeavored to imitate the beauty of nature with the coloring matter of certain herbs, roots, stems of plants, bark of trees, seed, berries, nuts, lichens, blood of shellfish, etc. Their methods of dyeing involved practically no understanding of chemistry. A dyer was an artisan and not a chemist. Much dye was wasted in the dyeing processes and it was practically impossible for even the most skilled dyer to exactly duplicate a color. The same dye gave several different results on a similar fiber.

Throughout Europe the industry developed rapidly, contributing in many cases to the social well-being and economic progress of the people. Color continued to be a recognized mark of class distinction. The Flemish people became adept in the art of applying dyes and are credited with developing it in England, Scotland, and Ireland.

Natural dyes were extensively prepared and used. The cultivation of madder and indigo was an important business down to the latter part of the nineteenth century when alizarin and indigo were synthesized and introduced on the market in competition with the natural products. In 1868 France produced over eight million dollars worth of madder. Eight years later the production ceased. Natural indigo was not quite so easily disposed of. Its production, however, reached its maximum in the year 1896-1897, when there were 640,000 hectares (1,581,440 acres) under cultivation. The yearly consumption of indigo was about twelve million pounds. Since 1900, synthetic indigo has practically displaced the natural product.

The second period in the development of the dye industry began with Woulfe's discovery of picric acid in 1771. This was a glimpse into a new world of thought and activity and consequently we should not be surprised to find that further discoveries of great importance did not immediately follow. Woulfe's process for the production of picric acid, by the oxidation of indigo with nitric acid, was too expensive to be used commercially and picric acid was not satisfactorily produced until many years later, when it was discovered that it could be obtained cheaply by the nitration of phenol, a coal tar product. Woulfe's discovery, however, stimulated other chemists to work on indigo in an attempt to find out its composition—the most important of the early work being that of Chevreul in 1810; that of Erdmann and Laurent in 1841; and that of Erdmann in 1842. As a result of this pioneer work, isatin was obtained from indigo. This discovery pointed to the possible relation between the indigo molecule and that of isatin and was an important contributing factor in all the later synthesis of indigo. The impetus to investigation of the nature of dyes had been given and, as a natural consequence, the activity in the dye industry shifted from the art of extracting and applying natural dyes to the study of the scientific principles involved in the production and application of synthetic dyes. The synthesis of dyes was a great triumph over nature and opened up an attractive field of research.

In praising the men who actually synthesized dyes, we must not overlook the work of the pioneers in chemical analysis who made the discoveries possible. By careful analysis of natural substances, they led the way to the unraveling of Nature's secrets in building them up and thus introduced to their successors a world of extremely fascinating and highly profitable work.

In 1856, Perkin discovered mauvine, the synthesis of which was of great importance in shaping the course of the development

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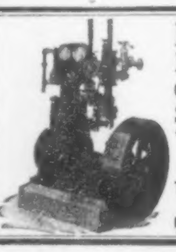

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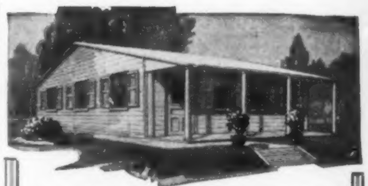
of the synthetic-dye industry. This was manufactured on an industrial scale the year following its discovery and it immediately became a commodity in great demand. Chance happened to play a considerable part in Perkin's discovery, consequently, exact scientific methods did not receive just recognition at the time and the youthful synthetic-dye industry began life in England without the support of pure science. This is a very important fact and partially explains why the new industry found German soil more conducive to its full development.

Like England, France was also a pioneer in the manufacture of synthetic dyes, but she gradually lost her grip on the industry, in competition with Germany, because of her inability to withstand the German organization; because of her careless neglect of pure science in connection with the manufacture of synthetic dyes; and because of the initial struggle of the synthetic dyes to overcome public prejudice in France where the natural dyes were available. French capital was interested largely in the production of natural dyes and consequently it did not see clearly the potentialities of the new phase of the dye industry.

The triumphs in the chemistry of dyes during the past fifty years have been nothing short of marvelous. Perkin's discovery of mauvine stimulated research on the oxidation of aniline with different reagents and led to Verguin's discovery that tin chloride would convert crude aniline into magenta (Fuchsine). In 1860, Nicolson, Girard and de Laire worked out a satisfactory method of preparing magenta on a commercial basis and thus made possible the production of a wider range of colors with synthetic dyes. In the same year, they produced rosaniline blue, the first synthetic blue dye, by treating magenta with aniline. In the following year Lauth synthesized methyl violet and Nicolson made chrysaniline. In 1862 Nicolson made another contribution to science in the discovery of water blue, or the sodium sulphonate of rosaniline. In the same year, Cherpin discovered aldehyde green, the first green synthetic dye, and Lightfoot prepared aniline black—a dye of great importance even to-day. About 1865, Kekulé proposed his theory of the structure of the benzene molecule and exact investigations in dye chemistry received a very noticeable impetus, especially in Germany. Three years later, Graebe and Liebermann and Perkin independently synthesized alizarin, the chief dye of madder. This was one of the greatest achievements of pure science. Of no less importance was the struggle of this synthetic dye to displace madder. It was only after years of careful and systematic research to establish the best and most efficient methods of applying this dye that it finally triumphed over the natural product.

After twenty years of costly research synthetic indigo was made possible. This product was far superior to the natural substance and this fact helped it in its struggle against public prejudice. Many chemists contributed to the solution of the synthetic indigo problem. Baeyer, Drewson, and Heumann should receive special mention for their brilliant contributions. No one of the chemists who worked on this problem could have solved it without financial support. The Badische Aniline and Soda-Fabrik spent over one hundred thousand dollars in developing Baeyer's patents without reward. It was only after the discovery that napthalene could be used as an initial substance in the manufacture of indigo that it was able to compete with the natural product. To-day, synthetic indigo and its derivatives are indispensable in the textile industry. The beautiful Tyrian Purple was found by Friedlander to be 2:6-dibromindigo. It is not necessary now to secure it from the blood of shellfish at an enormous cost. It can be manufactured from napthalene in large quantities.

There are nine hundred or more synthetic dyes on the market to-day and everyone of them has meant a new triumph for chemical science. The combined efforts of Kekulé, Witt, Peter Griess, Caro, Martius and Rousseu made possible the development of the Azo dyes which repre-



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sent over 50 per cent of the dyes in common use. Finally, the Vat dyes have been discovered during the past fifteen years and extremely fast, brilliant colors can now be produced.

The greatest and most important part of this activity has been confined to Germany where the dye industry seemed to find conditions most favorable for its unrestricted development. Kekulé's theory of valence was easily assimilated by the German chemists and immediately they calmed their doubts and substituted exact methods of research for mere philosophical speculation. Pure science was selected as the foundation upon which to build the dye industry. Time has shown this to have been wise.

The German chemists' faith in the ultimate success of the application of theoretical chemistry to practical problems and their absolute certainty inspired the confidence of capital to venture the support of the promising infant industry without the assurance of immediate returns on its investment. Of course, it must not be supposed that either extraordinary foresight or generosity was responsible for the eager willingness of German capital to lend a protecting arm to this new industry. Careful analysis of the situation reveals the fact that it was international business rivalry which prompted the investments and patiently supported the project, calmly awaiting the fruition of its potential promises. Natural dyes were chiefly in the control of England and France. Germany saw a chance to displace their dyes by better products, whose properties could be guaranteed to be always the same, and thus win over the business. Theory and practice were solidly allied together to win success, even at heavy initial costs, and a systematic and thorough organization of work resulted. To organized co-operative research, Germany owes much of her success in the dye industry. The research laboratory has been an indispensable unit in her factory equipment. It has been the nucleus and its importance has been thoroughly recognized. Eminent chemists have directed its work and caused its influence to be favorably felt and genuinely appreciated. Masses of information needed in the development of an industry so complex and diversified have been compiled with the least possible expenditure of energy and money and made available for the use of the productive part of the factory. The soundness and value of such a systematic scientific foundation has been unquestionably demonstrated.

Not only has the German manufacturer of dyes been successful in enlisting an army of thoroughly trained chemists and technologists to solve his problems, but he has also learnt how to use labor so as to get its greatest efficiency and at the same time engender in it a spirit of contentment. The splendid way that employees are treated by the large German dye manufacturers speaks volumes for the friendly spirit of co-operation between labor and capital and ultimately is a large contributing factor to the success of the industry.

Here in America we might take note of the factors involved in the German success in the development of the dye industry before undertaking to transplant it to our soil, realizing that "rule-of-thumb" methods can never be productive of genuine permanent results in this field and that to satisfactorily meet the competition of the German organization we must establish the industry on a thoroughly scientific basis. We should expect keen competition when the war is over, but in spite of this an American dye industry should survive if organized on the principles which have led to the German supremacy in the tinctorial world.

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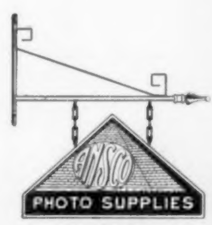

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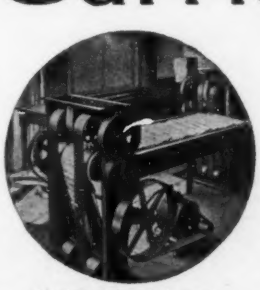

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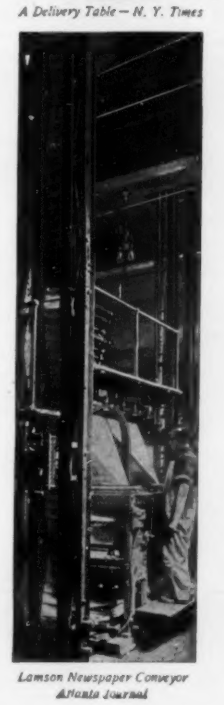

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nite location at first, being placed on some models in the seat post of the diamond frame taken over from the bicycle, and the tank for fuel and oil was commonly suspended on the mudguard over the rear wheel.

In successive years, however, the diamond frame has given way to a modified loop frame and the engine has been located in the loop, the motor base or crankcase taking the place of the old crank hanger of the bicycle and the tank for gasoline and oil being fastened above it. The frame is made of forged steel, which is heavier than formerly, the joints brazed electrically or by the oxy-acetylene method of welding, contributing to long life and wear. A motorcycle nowadays is of either the single or two-cylinder type, ranging in power from 3½ to 7, 8 and 10 horsepower, with some variations to four-cylinder machines.

The power control is from the grips, one of the grips controlling the compression and the electric spark and the other the throttle, which regulates the supply of gas to the combustion chamber. This gives the rider of the American machine more effective control than on the foreign makes, where there is a confusing multiplicity of levers to regulate the speed of the engine. On some American machines there is a hand brake operating a contracting band brake on the rear hub, and in addition an internal expanding brake which may be operated by the foot. On the newer models the rider's hand finds within easy reach levers to control the gear shift and thus secure change of speed, and other levers to throw in or release the engine clutch.

The transmission from the engine to the hub of the rear wheel is commonly by means of two drive chains, from engine shaft to countershaft, which carries the gearset, and thence to the sprocket of the rear wheel. A few models maintain the belt drive, with idler pulley. The engine is thrown into engagement with the driving mechanism by means of a clutch, which is either of the multiple friction disk, cone or band type. The gasoline motors have been so improved and start with such quickness and reliability that the pedals, which were first employed to get the engine going and to give assistance on the hills, have now been discarded in favor of a kick or step starter, the driver being provided with footrests which are brazed on the frame. All machines now carry a rear stand on which they may be supported, when not in use.

Prominent among improvements of recent years are the cradle spring frame, consisting of leaf springs fitted in the fork and rear structure of the frame, which take the weight of the engine and rider and make the machine easy riding on hard roads. Electrical equipment is another feature, a magneto generator which is driven by the engine furnishing the electric spark for ignition of the gas in the motor and current for lighting headlight and rear lamp, besides charging a battery.

It is estimated that there are in use in this country 180,000 registered motorcycles. A Government report gives California, where weather conditions permit riding the year around, as the first State in the number of enrollments, having 24,709 in 1914; New York second, with an estimated total of 24,000 machines; Ohio third, with 20,637 machines registered, and Illinois fourth, with a total of 14,852. Then follow Pennsylvania, with 14,592; Indiana, 10,403; New Jersey, 10,029; Kansas, 8,068; Massachusetts, 8,161; Iowa, 7,318; Wisconsin, 7,880; Michigan, 7,000; Washington, 4,000; Colorado, 3,863; and so on through the list, the registration ranging between 1,000 and 3,000 per State.

The fastest time ever made on a motorcycle was a mile in 36 seconds. It has frequently been driven at speeds of 80 and 90 miles an hour in races and has maintained an average of more than 60 miles in many long-distance races. In a transcontinental trip from San Diego, Cal., to New York city in 1914 a motorcycle covered 3,378.9 miles in 11 days 12 hours 10 minutes, Erwin G. Baker riding it throughout the trip.

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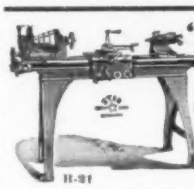
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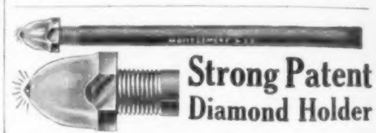
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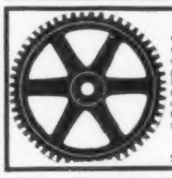
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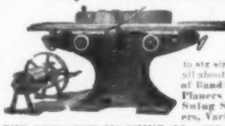
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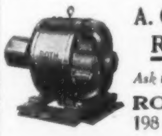
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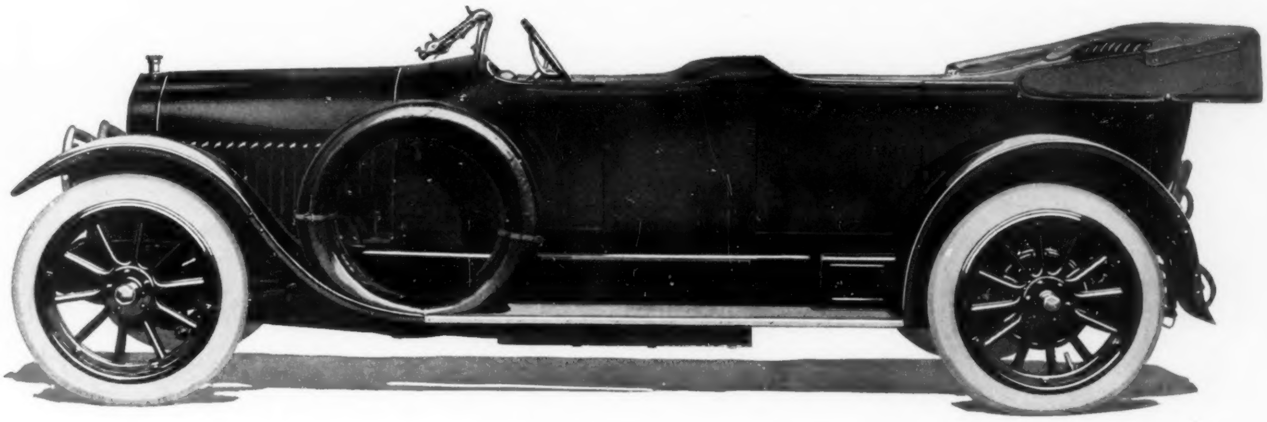

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These "imitations" are clever—but imitations have their limitations.

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It is one proposition to buy something because it looks a little bit like another.

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The White body, IN ITS COMPLETENESS, makes made-to-order automobile bodies unnecessary for even the most critical taste.

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And there, after all, is the true standard of value. Looks, without SERVICE, would be an imitation of what you want.

❖ ❖ ❖

Leadership must and does create value.

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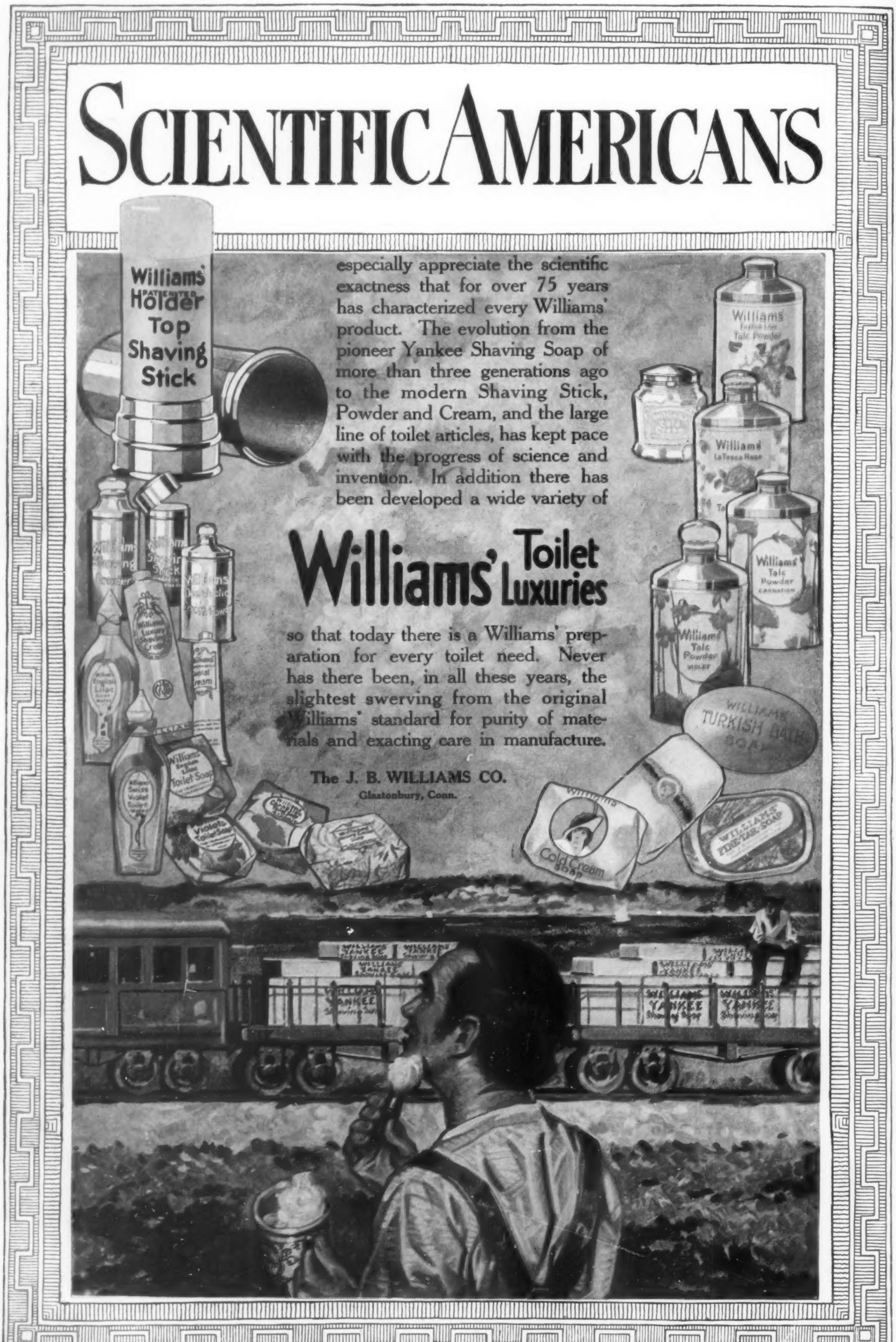
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